

## DECLARATION

I, Young Woo Park, Korean Patent Attorney of 5F, Seil Building, 727-13, Yeoksam-dong, Gangnam-gu, Seoul, Korea do hereby solemnly and sincerely declare as follows:

1. That I am well acquainted with the English and Korean languages.
2. That the following is a correct translation into English of the accompanying certified copy of a Korean Patent Application No. 2003-16477.

and I make the solemn declaration conscientiously believing the same to be true.

Seoul, September 29, 2006

Young-Woo PARK



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**COMMISSIONER**



## PATENT APPLICATION

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Title of the Invention: ARRAY SUBSTRATE AND TRANS REFLECTIVE  
TYPE LIQUID CRYSTAL DISPLAY HAVING THE SAME

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To the COMMISSIONER



[ABSTRACT]

[ABSTRACT]

A reflective-transmissive type LCD apparatus for preventing occurrence of the afterimage and enhancing a contrast ratio is presented. A reflecting plate, which is formed on a pixel electrode connected to a switching device formed on an array substrate, defines a reflecting area from which a natural light is reflected and a transmitting area through which an artificial light is transmitted. The reflecting plate is partially extended to and overlapped with the transmitting area depending upon a rubbing direction of the array substrate. Thus, the reflective-transmissive type LCD apparatus may prevent occurrence of the afterimage, and may enhance the contrast ratio thereof when operated in a transmissive mode.

[REPRESENTATIVE FIGURE]

FIG. 1

[INDEX WORD]

Liquid crystal, Reflective-transmission, Transflective type, Overlap, Reflecting plate, Pixel electrode, Rubbing direction



[SPECIFICATION]

[TITLE OF THE INVENTION]

ARRAY SUBSTRATE AND TRANS-REFLECTIVE TYPE LIQUID CRYSTAL  
DISPLAY HAVING THE SAME

[BRIEF EXPLANATION OF THE DRAWINGS]

FIG. 1 is a plan view explaining a reflective-transmissive type liquid crystal display apparatus according to an exemplary embodiment of the present invention;

FIG. 2 is a cross-sectional view taken along the line A-A' of FIG. 1;

FIG. 3 is an enlarged view showing a boundary area between the reflecting area and the transmitting area of the reflective-transmissive type LCD apparatus shown in FIG. 2;

FIGS. 4A to 4D are views illustrating a method of manufacturing the reflective-transmissive type LCD apparatus according to an example embodiment of the present invention;

FIGS. 5A to 5D are views illustrating a method of manufacturing the reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention;

FIG. 6 is a plan view explaining a reflective-transmissive type liquid crystal display apparatus according to another exemplary embodiment of the present invention;

FIG. 7 is a cross-sectional view taken along the line B-B' of FIG. 6;

FIG. 8 is an enlarged view showing a boundary area between the reflecting area and the transmitting area of the reflective-transmissive type LCD apparatus shown in FIG. 7;

FIGS. 9A to 9D are views illustrating a method of manufacturing the reflective-

transmissive type LCD apparatus according to another example embodiment of the present invention in FIG. 6;

FIG. 10 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to an exemplary embodiment of the present invention;

FIG. 11 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention;

FIG. 12 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention;

FIG. 13 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention; and

FIGS. 14A to 14D are plan views explaining various reflective-transmissive type LCD apparatuses.

#### <EXPLANATION ON CHIEF REFERENCE NUMERALS OF DRAWINGS >

100 : array substrate	119, 120 : source line
109, 409 : gate line	142, 150, 450 : pixel electrode
145, 470 : transmissive window	160, 460 : reflecting plate
200 : color filter substrate	210 : color filter layer
300 : liquid crystal layer	

[DETAILED DESCRIPTION OF THE INVENTION]

[PURPOSE OF THE INVENTION]

## [THE ART TO WHICH THE INVENTION PERTAINS AND THE PRIOR ART]

The present invention relates to an array substrate and a reflective-transmissive type liquid crystal display (LCD) apparatus having the array substrate, and more particularly to an array substrate capable of removing an afterimage and enhancing a contrast ratio and a reflective-transmissive type LCD apparatus having the array substrate.

In general, a reflective-transmissive type LCD apparatus employing liquid crystal of a mixed twisted nematic (MTN) mode has advantages, for example, such as a high contrast ratio, a high productivity, a high color quality and so on. However, since the reflective-transmissive type LCD apparatus has the liquid crystal twisted, a light transmittance may be deteriorated while the reflective-transmissive type LCD apparatus is operated in a transmissive mode. The liquid crystal of the MTN mode is, generally, twisted in an angle smaller than 90 degrees.

In recent, in order to prevent deterioration of the light transmittance of the MTN mode liquid crystal, a homogeneous mode liquid crystal that the liquid crystal is not twisted is widely used.

In case that the liquid crystal is aligned in the homogenous mode, a cell gap corresponding to a reflecting area and a cell gap corresponding to a transmitting area are different from each other. Especially, when a value of  $\Delta n_d$  corresponding to the reflecting area is  $0.13\mu$  and a value of  $\Delta n_d$  corresponding to the transmitting area is  $0.26\mu$ , the cell gap corresponding to the transmitting area is twice larger than the cell gap corresponding to the reflecting area. If the liquid crystal has an anisotropic refractive index ( $\Delta n$ ) of 0.078, the cell gap corresponding to the reflecting area is  $1.7\mu$  and the cell gap corresponding to the transmitting area is  $3.3\mu$ .

The cell gap corresponding to the reflecting area may be different from the cell

gap corresponding to the transmitting area due to an organic insulating layer formed on an array substrate. A disclination, however, may occur at a boundary area between the reflecting area and the transmitting area, and the light may be leaked due to a distorted alignment of the liquid crystal. As a result, an afterimage may appear on a display screen, and a contrast ratio may be lowered.

#### [TECHNICAL OBJECT OF THE INVENTION]

Accordingly, the present invention is provided to substantially obviate one or more problems due to limitations and disadvantages of the related art.

The present invention provides an array substrate capable of removing an afterimage and enhancing a contrast ratio.

The present invention also provides a reflective-transmissive type liquid crystal display apparatus having the above array substrate.

#### [CONSTRUCTION AND FUNCTION OF THE INVENTION]

In one aspect of the present invention, an array substrate includes a substrate, a switching device formed in an area defined by a gate line and a source line, a pixel electrode connected to a drain electrode of the switching device, and a reflecting plate formed on the pixel electrode.

The gate line is formed in a first direction, and the source line is formed in a second direction.

The switching device includes a gate electrode extended from the gate line, a source electrode extended from the source line and the drain electrode spaced apart from the source electrode.

The reflecting plate defines a reflecting area from which a natural light is reflected and a transmitting area through which an artificial light is transmitted, and includes a portion of an edge extended to the transmitting area.



In another aspect of the present invention, a reflective-transmissive type liquid crystal display apparatus includes an upper substrate, a lower substrate, and a liquid crystal layer interposed between the upper and lower substrates.

The upper substrate includes a color pixel, and the color pixel has a first thickness at a position corresponding to a reflecting area and a second thickness at a position corresponding to a transmitting area, which is thicker than the first thickness.

The lower substrate includes a switching device, a pixel electrode connected to a drain electrode of the switching device, and a reflecting plate formed on the pixel electrode.

The reflecting plate defines the reflecting area from which a natural light is reflected and the transmitting area through which an artificial light is transmitted, and includes an edge partially extended to the transmitting area.

In still another aspect of the invention, in a reflective-transmissive type liquid crystal display apparatus that displays an image using an artificial light or a natural light passing through a liquid crystal layer, the reflective-transmissive type liquid crystal display apparatus includes a first substrate, a switching device formed in an area that is defined by a gate line and a source line disposed on the first substrate, a pixel electrode connected to a drain electrode of the switching device, and a reflecting plate disposed on the pixel electrode

The gate line is formed in a first direction, and the source line is formed in a second direction.

The reflecting plate defines a reflecting area from which the natural light is reflected and a transmitting area through which the artificial light is transmitted, and includes a portion of an edge extended to the transmitting area.

In still another aspect of the invention, In a liquid crystal display apparatus that

displays an image using an artificial light or a natural light passing through a liquid crystal layer, the liquid crystal display apparatus includes a first substrate, a switching device formed in a pixel area that is defined by a gate line and a source line disposed on the first substrate, the gate line formed in a first direction, the source line formed in a second direction, and the switching device having a gate electrode extended from the gate line, a source electrode extended from the source line and a drain electrode spaced apart from the source electrode, a gate insulating layer formed on the switching device and the substrate, a pixel electrode formed on the gate insulating layer and connected to the drain electrode, for exposing the drain electrode of the switching device, an organic insulating layer formed on the switching device and the pixel electrode to expose the gate insulating layer corresponding to the transmitting area, an inter-insulating layer formed on the organic layer corresponding to the reflecting area, and a reflecting plate disposed on the pixel electrode so as to define the reflecting area and the transmitting area, the reflecting area having a first edge extended to the transmitting area to connect the reflecting plate to the pixel electrode.

According to the reflective-transmissive type liquid crystal display apparatus, a portion of the reflecting plate is extended to and overlapped with the transmitting area depending upon the rubbing direction of the liquid crystal layer. Thus, the reflective-transmissive type LCD apparatus may prevent occurrence of the afterimage and leakage of light, and may enhance a contrast ratio thereof when operated in a transmissive mode.

Hereinafter, the present invention will be described in detail with reference to the accompanied drawings.

FIG. 1 is a plan view explaining a reflective-transmissive type liquid crystal

display apparatus according to an exemplary embodiment of the present invention. In this exemplary embodiment, an array substrate for a reflective-transmissive type liquid crystal display apparatus having a structure of top-ITO will be described.

Referring to FIG. 1, an array substrate 100 includes a gate line 109 extended in a substantially horizontal direction and arranged in a substantially vertical direction, a source line 119 extended in the vertical direction and arranged in the horizontal direction, a switching device TFT formed in an area defined by the gate and source lines 109 and 119, a pixel electrode 150 electrically connected to a drain electrode 130, and a reflecting plate 160 formed on the pixel electrode 150 so as to define a reflecting area from which a natural light is reflected and a transmitting area through which an artificial light is transmitted.

The switching device TFT includes a gate electrode 110 extended from the gate line 109 and, a source electrode 120 extended from the source line 119 and a drain electrode 130 spaced apart from the source electrode 120.

The array substrate 100 may include a plurality of gate lines and a plurality of source lines instead of including a single gate line and a single source line as described above.

The reflecting plate 160 includes an edge that is partially extended from the reflecting area to the transmitting area and connected to the pixel electrode 150.

In this exemplary embodiment, the reflecting plate 160 formed on the reflecting area is partially extended to a transmissive window 145 in consideration of a rubbing direction of an alignment layer (not shown) formed on the array substrate 100, and connected to the pixel electrode 150 disposed thereunder. Particularly, when viewed the array substrate 100 at an upper position in FIG. 1, the reflecting plate 160 is connected to the pixel electrode 150 due to an extension of edge of the

reflecting area adjacent to bottom and right sides of the transmissive window 145 in case of rubbing the alignment layer in 10 o'clock.

FIG. 2 is a cross-sectional view taken along the line A-A' of FIG. 1.

Referring to FIGS. 1 and 2, the reflective-transmissive type liquid crystal display (LCD) apparatus includes the array substrate 100, a color filter substrate 200 and a liquid crystal layer 300 disposed between the array substrate 100 and the color filter substrate 200.

The array substrate 100 includes a transparent substrate 105, a switching device 111 having a gate electrode 110 formed on the transparent substrate 105, a gate insulating layer 112 formed on the gate electrode 110 and the transparent substrate 105, a semiconductor layer 114, an ohmic contact layer 116 and a source electrode 120, an organic insulating layer 140 formed to cover a switching device TFT and partially to expose the drain electrode. The organic insulating layer 140 further includes a groove and a protrusion formed on a surface thereof.

Additionally, the array substrate 100 includes the pixel electrode 150 that is formed on the organic insulating layer 140 and connected to the drain electrode 130 through the first contact hole 141, an inter-insulating layer 152 formed to cover the switching device and the reflecting plate 160 formed on the inter-insulating layer 152. A reflecting area is defined as an area on which the reflecting plate 160 is formed, and a transmissive window 145 is defined as an area on which the reflecting plate 160 is not formed.

The pixel electrode 150 acts as a transmissive electrode through which light is transmitted, and comprises indium tin oxide (ITO), tin oxide (TO) or indium zinc oxide (IZO), etc. Although not shown in FIG. 2, the array substrate 100 may include a capacitor line (not shown) that acts as a storage capacitor with the pixel electrode

150. The capacitor line is formed and spaced apart from the switching device 111 before the pixel electrode 150 is formed.

In this exemplary embodiment, the reflecting plate 160 is formed on the inter-insulating layer 152 corresponding to the reflecting area. The edge of the reflecting plate 160, which is adjacent to the transmitting area, is partially extended toward the transmitting area by a predetermined length "L". In FIG. 2, the reflecting plate 160 insulated from the pixel electrode 150 by the inter-insulating layer 152 disposed therebetween is shown. The inter-insulating layer 152, however, may be partially removed, so that the reflecting plate 160 may be electrically connected to the pixel electrode 150.

The color filter substrate 200 includes a transparent substrate 205, a black matrix (not shown) formed on the transparent substrate 205 so as to define red (R), green (G) and blue (B) pixel areas, a color pixel layer 210 formed in the R, G and B pixel areas and a surface passivation layer (not shown) for protecting the black matrix and the color pixel layer 210. In case that the color pixel layer 210 is formed to be partially overlapped with an adjacent color pixel layer, the black matrix of the color filter substrate 200 may be removed. The color filter substrate 200 may further include a common electrode layer (not shown) formed on the surface passivation layer.

The liquid crystal layer 300 disposed between the array substrate 100 and the color filter substrate 200 transmits natural light passing through the color filter substrate 200 or transmits artificial light passing through a transmission window 145 in response to a voltage signal applied to the pixel electrode 150 of the array substrate 100 and a voltage signal applied to a common electrode layer (not shown) of the color filter substrate 200. The liquid crystal layer 300 has a different cell gap at

each of a first area at which a first contact hole 141 is formed, a second area at which the first contact hole 141 is not formed and a third area. The first and second areas correspond to the reflection area, and the third area corresponds to the transmitting area. The cell gap of the liquid crystal layer 300 corresponding to the first area, the cell gap of the liquid crystal layer 300 corresponding to the second area and the cell gap of the liquid crystal layer 300 are represented as  $d_1$ ,  $d_2$  and  $d_3$ , respectively. Here, a thickness of the liquid crystal layer 300 for each different cell gap meets a condition of  $d_2 < d_1 < d_3$ .

Especially, assuming that the anisotropic refractive index of liquid crystal molecules of the liquid crystal layer and the cell gap are represented by  $\Delta n$  and  $d$ , respectively, the liquid crystal layer 300 has a condition of  $\Delta n d_1$  in the first area because the organic insulating layer are not formed in the first area, the liquid crystal layer 300 has a condition of  $\Delta n d_2$  in the second area because the organic insulating layer are formed in the first area, and the liquid crystal layer 300 has a condition of  $\Delta n d_3$  in the third area because only the source-drain insulating layer 140 is formed in the first area.

The cell gap concerning the reflecting area and the transmitting area depends upon the liquid crystal molecules of the liquid crystal layer 300 and an optical film disposed on and under the liquid crystal layer 300. However, the cell gap  $d_2$  corresponding to the reflecting area is less than about  $1.7\mu$ , and the cell gap  $d_3$  corresponding to the transmitting area is less than about  $3.3\mu$ .

In addition, since the liquid crystal layer 300 is treated by homogeneous alignment treatment, the liquid crystal layer 300 includes the liquid crystal molecules having a twisted angle of zero.

In FIG. 2, in order to allow the liquid crystal molecules to have the twisted

angle of zero, an alignment layer (not shown) formed on the array substrate 100 is rubbed in a right direction that is a first direction, and an alignment layer (not shown) formed on the color filter substrate 200 is rubbed in a left direction that is a second direction. The first and second directions are opposite to each other. Thus, an edge of the reflecting plate 160, which is positioned at a side of the switching device 111, will be extended in the transmission window 145. If the alignment layer formed on the array substrate 100 is rubbed in the second direction and the alignment layer formed on the color filter substrate 200 is rubbed in the first direction, an edge of the reflecting plate 160, which is positioned at a far side from the switching device 111, will be extended in the transmission window 145.

A method for applying the voltage to both sides of the liquid crystal layer 300 after forming the pixel electrode 150 on the array substrate 100 and the common electrode layer (not shown) on the color filter substrate 200, respectively, has been described. In case that the common electrode layer (not shown) is, however, not formed on the color filter substrate 200, the reflective-transmissive type LCD apparatus may reflect the natural light and transmit the artificial light by applying various voltages having different voltage levels from each other onto one surface of the array substrate 100.

FIG. 3 is an enlarged view showing a boundary area between the reflecting area and the transmitting area of the reflective-transmissive type LCD apparatus shown in FIG. 2.

Referring to FIGS. 2 and 3, the reflecting plate 160 formed on the organic insulating layer 144 is partially extended to the transmission window 145 that defines the transmitting area without the organic insulating layer 144 formed thereon.

For example, a portion of the edge of the reflecting plate 160, which is

adjacent to the transmission window 145, is extended to the transmission window 145 according to the rubbing direction for the liquid crystal layer 300. Thus, loss of the natural light NL and the artificial light AL due to a transmittance and a reflectance of the reflective-transmissive type LCD apparatus may be minimized. Furthermore, the reflective-transmissive type LCD apparatus may prevent occurrence of the afterimage and leakage of the light caused by a difference of the cell gap between the reflecting area and the transmitting area.

FIGS. 4A to 4D are views illustrating a method of manufacturing the reflective-transmissive type LCD apparatus according to an example embodiment of the present invention. Particularly, in FIGS. 4A to 4D, a method of manufacturing the array substrate shown in FIG. 1 will be described.

Referring to FIG. 4A, a metal layer comprising a metal material, for example, such as tantalum (Ta), titanium (Ti), molybdenum (Mo), aluminum (Al), chromium (Cr), copper (Cu), tungsten (W), etc., is formed on the transparent substrate 105 comprising an insulating material, for example, such as glass, ceramic and so on. Subsequently, the gate line 109 extended in the horizontal direction and successively arranged in the vertical direction and the gate electrode 110 extended from the gate line 109 are formed when the metal layer is patterned.

Although not shown in FIG. 4A, a storage electrode line is also formed when the gate electrode 110 is formed. In addition, to form the gate insulating layer 112 (see FIG. 1), silicon nitride is deposited over the substrate using a plasma-enhanced chemical vapor deposition method. In the following, an amorphous silicon layer and an  $n^+$  amorphous silicon layer are successively formed on the gate insulating layer, and patterned to form the semiconductor layer 114 and the ohmic contact layer 116. As shown in FIG. 4B, a metal layer having a metal material, for example, such as



tantalum (Ta), titanium (Ti), molybdenum (Mo), aluminum (Al), chromium (Cr), copper (Cu), tungsten (W), etc., is formed on the substrate on which the resultant structure shown in FIG. 4A is formed. Later, when the metal layer is patterned, the source line 119 extended in the vertical direction and successively arranged in the horizontal direction, the source electrode 120 extended from the source line 119 and the drain electrode 130 spaced apart from the source electrode 120 are formed.

Referring to FIG. 4C, the organic insulating layer 144 are successively formed on the resultant structure of the substrate shown in FIG. 4. Then, the organic insulating layer 144 corresponding to the transmitting area, and the organic insulating layer 144 corresponding to the drain electrode 130 are removed to form the first contact hole 141 and the transmission window 145. An ITO layer is formed on the pixel area defined by the gate line 109 and the source line 119 so as to form the pixel electrode 150. The pixel electrode 150 is electrically connected to the drain electrode 130 through the first contact hole 141. The pixel electrode 150 may be formed by forming the ITO layer on the organic insulating layer 144 and by patterning the ITO formed on the organic insulating layer 144, such that the patterned ITO remains only on the pixel area. The pixel electrode 150 may be formed by forming the ITO only on the pixel area. As shown in FIG. 4C, when a distance L2 where the pixel electrode 150 and the source line 119 are overlapped with each other and a distance L3 where the pixel electrode 150 and the gate line 109 are overlapped with each other become smaller, an opening ratio of the transmission window may be enhanced.

Referring to FIG. 4D, the reflecting plate 160 is formed on a position corresponding to the pixel area defined by the gate line 109 and the source line 119. The reflecting plate 160 includes a groove 162 and a protrusion 164 corresponding to the concavo-convex shape of the organic insulating layer 144 so as to enhance the

reflection efficiency of the natural light NL. The reflecting plate 160 is also formed on a position corresponding to the reflecting area, and partially extended to the transmitting area.

A structure that an area defined by an outside of the gate line and an outside of the source line is formed to be larger than an area on which the pixel electrode is formed, has been shown. In this exemplary embodiment, the pixel electrode, however, may be acted as a capacitor with the gate line or the source line, so that a parasitic capacitance may occur.

In order to reduce the parasitic capacitance, a method that reduces an overlapped area of the pixel electrode and the gate line, or an overlapped area of the pixel electrode and the source line may be used.

FIGS. 5A to 5D are views illustrating a method of manufacturing a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention. In this exemplary embodiment, an array substrate for a reflective-transmissive type LCD apparatus having a top-ITO structure will be described.

In FIGS. 5A to 5D, the same reference numerals denote the same elements in FIG. 1, and thus the detailed descriptions of the same elements will be omitted. Particularly, in FIGS. 5A and 5B, the same elements represented by the same reference numerals in FIGS. 4A and 4B are formed through same processes of the same elements in FIG. 4A and 4B, and thus the detailed descriptions of the same processes will be also omitted.

Referring to FIG. 5C, an ITO layer is formed on the pixel area defined by a gate line 109 and a source line 119 so as to form a pixel electrode 151. The pixel electrode 151 is electrically connected to a drain electrode 130 through a first contact hole 141. The pixel electrode 151 may be formed by forming the ITO layer on a

source-drain insulating layer 140 and an organic insulating layer 144 and by patterning the ITO, such that the patterned ITO remains only on the pixel area. When viewed on a plane, the pixel electrode 151 may be formed by forming the ITO only on the pixel area. In this exemplary embodiment, the pixel electrode 151 is not overlapped with the source line 119.

As shown in FIG. 5D, a reflecting plate 160 is formed on a position corresponding to the pixel area defined by the gate line 109 and the source line 119. The reflecting plate 160 includes a groove 162 and a protrusion 164 corresponding to a concavo-convex shape of the organic insulating layer 144 so as to enhance a reflection efficiency. The reflecting plate 160 is formed on a position corresponding to a reflecting area, and partially extended to the transmitting area, thereby partially connecting the reflecting plate 160 to the pixel electrode 142.

FIG. 6 is a plan view explaining a reflective-transmissive type liquid crystal display apparatus according to another exemplary embodiment of the present invention. In this exemplary embodiment, an array substrate for a reflective-transmissive type liquid crystal display apparatus having a structure of bottom-ITO will be described.

Referring to FIG. 6, an array substrate 400 includes a transparent substrate 405, a gate line 409 formed on the transparent substrate 405, extended in a first direction and arranged in a second direction substantially perpendicular to the first direction, a source line 419 disposed on the transparent substrate 405, extended in the second direction and arranged in the first direction, a switching device TFT formed in an area defined by the gate and source lines 109 and 119, a pixel electrode 450 electrically connected to the drain electrode 430, and a reflecting plate 460 formed on the pixel electrode 450 so as to define a reflecting area from which a

natural light is reflected and a transmitting area or a transmission window 445 through which an artificial light is transmitted.

The switching device TFT includes a gate electrode 410 extended from the gate line 409 and, a source electrode 420 extended from the source line 419 and a drain electrode 430 spaced apart from the source electrode 420.

Alternatively, the array substrate 400 may include a plurality of gate lines and a plurality of source lines.

The reflecting plate 460 includes an edge partially extended from the reflecting area to the transmitting area and connected to the pixel electrode 450.

In this exemplary embodiment, the reflecting plate 460 formed on the reflecting area is partially extended to the transmissive window 145 in consideration of a rubbing direction of an alignment layer (not shown) formed on the array substrate 400, and connected to the pixel electrode 450 disposed thereunder. Particularly, when viewed the array substrate 400 at an upper position in FIG. 6, the reflecting plate 460 is connected to the pixel electrode 450 due to an extension of edge of the reflecting area adjacent to bottom and right sides of the transmissive window 445 in case of rubbing the alignment layer in 10 o'clock.

FIG. 7 is a cross-sectional view taken along the line B-B' of FIG. 6.

Referring to FIGS. 6 and 7, the reflective-transmissive type liquid crystal display (LCD) apparatus includes the array substrate 400, a color filter substrate 200 and a liquid crystal layer 300 disposed between the array substrate 400 and the color filter substrate 200.

The array substrate 100 includes the transparent substrate 405, the switching device TFT having the gate electrode 410 formed on the transparent substrate 405, a gate insulating layer 412 formed on the gate electrode 410 and the transparent

substrate 405, a semiconductor layer 414, an ohmic contact layer 416, the source electrode 420 and the drain electrode 430, and a source-drain insulating layer 440 formed on the switching device TFT and the gate insulating layer 412. The source-drain insulating layer 440 is formed with a contact hole 441 so as to partially expose the drain electrode 430.

The array substrate 400 further includes the pixel electrode 450 formed on the source-drain insulating layer 440 and connected to the drain electrode 430 through the contact hole 441, an organic insulating layer 444 formed on the reflecting area to cover the switching device 411, an inter-insulating layer 452 formed on the organic insulating layer 444 and the reflecting plate 460 formed on the inter-insulating layer 452. Hereinafter, an area on which the reflecting plate 460 is formed and an area without the reflecting plate 460 formed thereon is defined as the reflecting area and the transmission window 445, respectively. Especially, since the pixel electrode 450 is formed on an area except an area on which the switching device TFT is formed, a voltage signal may not be normally applied to a portion of the liquid crystal layer 300, which is adjacent to the switching device TFT.

In this exemplary embodiment shown in FIGS. 6 and 7, the color filter substrate 200 has same function and structure as those of the color filter substrate shown in FIG. 2, and thus the detailed descriptions of the color filter substrate in FIG. 7 will be omitted.

The liquid crystal layer 300 disposed between the array substrate 400 and the color filter substrate 200 transmits the natural light passing through the color filter substrate 200 or transmits the artificial light passing through a transmission window 445 in response to a voltage signal applied to the array substrate 100 and a voltage signal applied to the color filter substrate 200. The liquid crystal layer 300 has a

different cell gap at each of a first area corresponding to the reflecting area and a second area corresponding to the transmitting area. When the cell gap of the liquid crystal layer 300 corresponding to the first area and the cell gap of the liquid crystal layer 300 corresponding to the second area are represented by  $d_4$  and  $d_5$ , respectively, a thickness of the liquid crystal layer 300 satisfies a condition of  $d_4 < d_5$ .

Especially, the cell gap concerning the reflecting area and the transmitting area depends upon the liquid crystal molecules of the liquid crystal layer 300 and an optical film disposed on and under the liquid crystal layer 300. However, the cell gap  $d_4$  corresponding to the reflecting area is less than about  $1.7\mu$ , and the cell gap  $d_5$  corresponding to the transmitting area is less than about  $3.3\mu$ .

Also, since the liquid crystal layer 300 is treated by homogeneous alignment treatment, the liquid crystal layer 300 additionally includes the liquid crystal molecules having a twisted angle of zero. In order to allow the liquid crystal molecules to have the twisted angle of zero, an alignment layer formed on the array substrate 400 is rubbed in the first direction, and an alignment layer formed on the color filter substrate 200 is rubbed in the second direction. The first and second directions are opposite to each other.

A method for applying the voltage to both sides of the liquid crystal layer 300 after forming a common electrode layer on the array substrate 400 and on the color filter substrate 200 has been described. However, in case that the common electrode layer is not formed on the color filter substrate 200, the reflective-transmissive type LCD apparatus may reflect the natural light and transmit the artificial light by applying various voltages having different voltage levels from each other onto one surface of the array substrate 400.

FIG. 8 is an enlarged view showing a boundary area between the reflecting

area and the transmitting area of the reflective-transmissive type LCD apparatus shown in FIG. 7.

Referring to FIGS. 7 and 8, the reflecting plate 460 formed on the organic insulating layer 444 is partially extended to the transmission window 445 that defines the transmitting area without the organic insulating layer 144 formed thereon, and electrically connected to the pixel electrode 450. Particularly, the reflecting plate 160 needs not to be extended to the transmitting area and contacted with the pixel electrode 142 in FIG. 3. However, the reflecting plate 460 should be extended to the transmitting area and contacted with the pixel electrode 450 in FIG. 8. For example, a portion of the edge of the reflecting plate 460, which is adjacent to the transmission window 445, is extended to the transmission window 445 according to the rubbing direction for the liquid crystal layer 300. Thus, loss due to a transmittance and a reflectance of the reflective-transmissive type LCD apparatus may be reduced. Further, the reflective-transmissive type LCD apparatus may prevent occurrence of the afterimage and leakage of the light caused by a difference of the cell gap between the reflecting area and the transmitting area thereof.

FIGS. 9A to 9D are views illustrating a method of manufacturing the reflective-transmissive type LCD apparatus according to another example embodiment of the present invention in FIG. 6. Particularly, in FIGS. 9A to 9D, a method of manufacturing the array substrate shown in FIG. 6 will be described. In FIGS. 9A to 9D, the same reference numerals denote the same elements in FIG. 6, and thus the detailed descriptions of the same elements will be omitted.

Referring to FIG. 9A, a metal layer comprising a metal material, for example, such as tantalum (Ta), titanium (Ti), molybdenum (Mo), aluminum (Al), chromium (Cr), copper (Cu), tungsten (W), etc., is formed on the transparent substrate 405

comprising an insulating material, for example, such as glass, ceramic and so on. The gate line 409 extended in the horizontal direction and successively arranged in the vertical direction, and the gate electrode 410 extended from the gate line 409 are then formed when the metal layer is patterned.

Although not shown in FIG. 9A, a storage electrode line is also formed when the gate electrode 410 is formed. In order to form the gate insulating layer, silicon nitride is deposited over the substrate using a plasma-enhanced chemical vapor deposition method. Subsequently, an amorphous silicon layer and an  $n^+$  amorphous silicon layer are successively formed on the gate insulating layer 412, and patterned to form the semiconductor layer 414 and the ohmic contact layer 416.

As shown in FIG. 9B, a metal layer having a metal material, for example, such as tantalum (Ta), titanium (Ti), molybdenum (Mo), aluminum (Al), chromium (Cr), copper (Cu), tungsten (W), etc., is formed on the transparent substrate 405 on which the resultant structure shown in FIG. 9A is formed. When the metal layer is patterned, the source line 419 extended in the vertical direction and successively arranged in the horizontal direction, the source electrode 420 extended from the source line 419 and the drain electrode 430 spaced apart from the source electrode 420 are then formed.

Referring to FIG. 9C, the source-drain insulating layer 440 is formed on the resultant structure of the transparent substrate 405 shown in FIG. 9B. Here, the source-drain insulating layer 440 is patterned so as to partially expose the drain electrode 430.

An ITO layer is formed on the pixel area defined by the gate line 409 and the source line 419 so as to form the pixel electrode 450. The pixel electrode 450 is electrically connected to the drain electrode 430 through the contact hole 441. The pixel electrode 450 may be formed by forming the ITO layer over the source-drain



insulating layer 440 and by patterning the ITO formed on the source-drain insulating layer 440, such that the patterned ITO remains only on the pixel area. Alternatively, the pixel electrode 450 may be formed by forming the ITO only on the pixel area. As shown in FIG. 9C, when a distance L5 where the pixel electrode 450 and the source line 419 are overlapped with each other and a distance L6 where the pixel electrode 450 and the gate line 409 are overlapped with each other become smaller, an opening ratio of a transmitting area may be enhanced. The gate line 409 overlapped with the pixel electrode 450 acts as a gate line of a previous stage.

Referring to FIG. 9D, the organic insulating layer 444 is formed on the substrate shown in FIG. 9C. The organic insulating layer is partially patterned to form the transmission window 445, and the reflecting plate 460 is formed on an area corresponding to each pixel defined by the gate line 409 and the source line 419. In order to enhance the reflection efficiency, an upper surface of the organic insulating layer 444 has a concavo-convex shape. The reflecting plate 460 also includes a groove 462 and a protrusion 464 corresponding to the concavo-convex shape of the organic insulating layer 444 so as to enhance the reflection efficiency of the natural light NL.

As described above, in the reflective-transmissive type LCD apparatus having the bottom-ITO structure, the reflecting plate 460 is extended to the transmitting area. Thus, when viewed the array substrate 400 at an upper position thereof, an extension area of the reflecting plate 460 to the transmitting area has a reversed L-shape in case of rubbing the alignment layer in 10 o'clock, thereby preventing occurrence of afterimage and leakage of light of the reflective-transmissive type LCD apparatus having a non-uniform cell gap.

The reflective-transmissive type LCD apparatus having the bottom-ITO

structure may further enhance the reflection efficiency because the reflective-transmissive type LCD apparatus having the bottom-ITO structure does not need to form the contact hole connected to the drain electrode of the switching device.

FIG. 10 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to an exemplary embodiment of the present invention. In this exemplary embodiment, a reflecting plate considering occurrence of afterimage and leakage of light when an alignment layer of an array substrate is rubbed in a direction of 10 o'clock will be described.

Referring to FIG. 10, in each of pixel areas, a reflecting plate is formed in an area defining one pixel, so that defines a reflecting area, and defines a transmitting window through an opened area. In this exemplary embodiment, since the alignment layer of the array substrate is rubbed in a direction of 10 o'clock, a lower edge of the reflecting plate corresponding to a lower portion of the transmission window and right edge of the reflecting plate corresponding to a right portion of the transmission window are extended to the transmitting window. When the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a top-ITO, the extended lower and right edges of the reflecting plate may be insulated from the pixel electrode disposed thereunder. When the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a bottom-ITO, the extended lower and right edges of the reflecting plate must be connected to the pixel electrode disposed thereunder.

As described above, since the lower and right edges of the reflecting plate corresponding to the lower and right portions of the transmission window are extended to the transmission window, the reflective-transmissive type LCD apparatus

may prevent occurrence of deisclination and leakage of light. The reflective-transmissive type LCD apparatus may further prevent lowering of transmittance because the transmitting area when only the lower and right edges of the reflecting plate are extended to the transmission window is greater than the transmitting area when all edges of the reflecting area are extended to the transmission window.

In FIG. 10, the lower and right edges of the reflecting plate may be partially extended to the transmission window.

FIG. 11 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention. In this exemplary embodiment, a reflecting plate when an alignment layer of an array substrate is rubbed in a direction of 12 o'clock will be described.

Referring to FIG. 11, in each of pixel areas, a reflecting plate is formed in an area defining one pixel to define a reflecting area, and define a transmitting window having a rectangular shape though an opened area. The opened area acts as the transmitting area, and has generally a rectangular shape. In this exemplary embodiment, since the alignment layer of the array substrate is rubbed in a direction of 12 o'clock, a lower edge of the reflecting plate corresponding to a lower portion of the transmission window is extended to the transmitting window.

When the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a top-ITO, the extended lower and right edges of the reflecting plate may be insulated from the pixel electrode disposed thereunder. When the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a bottom-ITO, the extended lower and right edges of the reflecting plate must be connected to the pixel electrode disposed thereunder.

As described above, since the lower edge of the reflecting plate corresponding to the lower portion of the transmission window is extended to the transmission window, the reflective-transmissive type LCD apparatus may prevent occurrence of disclination and leakage of light.

The reflective-transmissive type LCD apparatus may further prevent lowering of transmittance because the transmitting area when only the lower edge of the reflecting plate is extended to the transmission window is greater than the transmitting area when all edges of the reflecting area are extended to the transmission window.

In FIG. 11, the lower edge of the reflecting plate may be partially extended to the transmission window.

FIG. 12 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention. In this exemplary embodiment, a reflecting plate considering occurrence of afterimage and leakage of light when an alignment layer of an array substrate is rubbed in a direction of 1 o'clock will be described.

Referring to FIG. 12, in each of pixel areas, a reflecting plate is formed in an area defining one pixel, to define a reflecting area and define a transmission window having a rectangular shape through an opened area. The opened area acts as the transmitting area, and has generally a rectangular shape. In this exemplary embodiment, since the alignment layer of the array substrate is rubbed in a direction of 1 o'clock, an area of the reflecting plate corresponding to a lower portion of the transmission window, and an area of the reflecting plate corresponding to a left portion of the transmission window are extended to the transmission window.

When the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a top-ITO, the extended lower and left edges of the reflecting plate may be insulated from the pixel electrode disposed thereunder. Whereas, when the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a bottom-ITO, the extended lower and left edges of the reflecting plate must be connected to the pixel electrode disposed thereunder.

As described above, since the lower and left edges of the reflecting plate corresponding to the lower and left portions of the transmission window are extended to the transmission window, the reflective-transmissive type LCD apparatus may prevent occurrence of disclination and leakage of light.

The reflective-transmissive type LCD apparatus may further prevent lowering of transmittance because the transmitting area when only the lower and left edges of the reflecting plate are extended to the transmission window is greater than the transmitting area when all edges of the reflecting area are extended to the transmission window.

In FIG. 12, the lower and left edges of the reflecting plate may be partially extended to the transmission window.

FIG. 13 is a plan view explaining a reflecting plate partially overlapped with a transmitting area of a reflective-transmissive type LCD apparatus according to another exemplary embodiment of the present invention.

Referring to FIG. 13, in each of pixel areas, a reflecting plate is formed in an area defining one pixel, to define a reflecting area and define a transmission window having a rectangular shape through an opened area. The opened area acts as the transmitting area, and generally has a rectangular shape. In this exemplary embodiment, when the alignment layer of the array substrate is rubbed in a direction

of 10 o'clock, an area corresponding to a lower portion of the transmission window and an area corresponding to a right portion of the transmission window are extended to the transmission window. An area corresponding to a left portion of the transmission window and an area corresponding to an upper portion of the transmission window are opened.

In this exemplary embodiment, when the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a top-ITO structure, the extended lower and right edges of the reflecting plate may be insulated from the pixel electrode disposed thereunder. However, when the reflective-transmissive type LCD apparatus to which the reflecting plate is applied has a bottom-ITO, the extended lower and right edges of the reflecting plate must be connected to the pixel electrode disposed thereunder.

As described above, since the lower and right edges of the reflecting plate corresponding to the lower and right portions of the transmission window are extended to the transmission window and the upper and left edges of the reflecting plate corresponding to the upper and left portions of the transmission window are opened, the reflective-transmissive type LCD apparatus may prevent occurrence of disclination and leakage of light.

The reflective-transmissive type LCD apparatus may prevent lowering of transmittance because the transmitting area when the lower and right edges of the reflecting plate are extended to the transmission window and the upper and left edges of the reflecting plate are opened is greater than the transmitting area when all edges of the reflecting area are extended to the transmission window.

In FIG. 13, the lower and right edges of the reflecting plate may be partially extended to the transmission window.

The disclination in 11 o'clock, 12 o'clock, 1 o'clock and 2 o'clock directions except at 10 o'clock direction is observed, so that the viewing angle in 10 o'clock direction is most preferable.

FIGS. 14A to 14D are plan views explaining various reflective-transmissive type LCD apparatuses. Particularly, FIG. 14A shows a comparative example 1 that an edge of an opening of a reflecting plate corresponds with a boundary of a transmitting area, FIG. 14B shows a comparative example 2 that an edge of an opening of a reflecting plate is overlapped with a transmitting area by about  $8\mu$ , FIG. 14C shows a comparative example 3 that an edge of an opening of a reflecting plate is overlapped with a transmitting area by about  $5\mu$ , and FIG. 14D shows a comparative example 4 that an edge of an opening of a reflecting plate is spaced apart from a transmitting area by about  $1.5\mu$ .

In the comparative example 1 shown in FIG. 14A, a reflecting plate has an opening substantially equal to that of a transmitting area in size. In this case, since a cell gap of a liquid crystal layer corresponding to a reflecting area is different from a cell gap of a liquid crystal layer corresponding to the transmitting area, light may be leaked. Especially, when the reflective-transmissive type LCD apparatus having the reflecting plate as in the comparative example 1 is operated in a transmissive mode or a reflective mode, a disclination that causes an afterimage does not occur. However, a contrast ratio may be lowered due to leakage of the light in a reversed L-shape when the reflective-transmissive type LCD apparatus is operated in the transmissive mode.

In the comparative examples 2 and 3 shown in FIGS. 14B and 14C, since the all four edges of the opening of the reflecting plate are overlapped with the transmitting area, the reflective-transmissive type LCD apparatus may prevent the

leakage of the light as described in the comparative example 1. In a comparison of the comparative examples 2 and 3 with the comparative example 1, however, a reflectance of the reflecting plate may be enhanced due to the reflecting plate extended to the transmitting area, thereby lowering the transmittance of the reflecting plate.

When the reflective-transmissive type LCD apparatus having the reflecting plate as in the comparative example 1 is operated in the reflective mode or the reflective-transmissive mode, the disclination occurs in an initial frame, and leakage of the light that affects the contrast ratio does not occur. Similarly, when the reflective-transmissive type LCD apparatus having the reflecting plate as the comparative example 1 is operated in the transmissive mode, the disclination occurs in an initial frame, and leakage of the light that affects the contrast ratio does not occur.

In case of the comparative example 4, since the transmitting area increases and the reflecting plate decreases, the transmittance may be enhanced and the reflectance may be lowered.

As described above, when the reflective-transmissive type LCD apparatus is operated in the transmissive mode, the contrast ratio may be uniformly maintained by partially extending the edges of the opening of the reflecting plate to the transmitting area in consideration of the rubbing direction of the liquid crystal layer.

Hereinafter, optical characteristics with respect to various comparative examples and embodiments according to the present invention will be described with reference to the following Table 1 and Table 2.

Table 1 represents the optical characteristics of the LCD apparatus operated in the reflective mode with respect to each of various comparative examples and



embodiments. Table 2 represents the optical characteristics of the LCD apparatus operated in the transmissive mode with respect to each of various comparative examples and embodiments.

Table 1

	Reflective mode					
	White (%)	Dark (%)	C/R	White		Color reproducibility (%)
				X	Y	
Comparative Example 5	8.4	0.23	36.5	0.3271	0.3779	25.7
Comparative Example 6	9.7	0.23	42.2	0.3348	0.3603	14.7
Comparative Example 7	11.9	0.3	39.7	0.3398	0.3671	15
Comparative Example 8	8.7	0.2	43.5	0.3310	0.3500	16.6
Comparative Example 9	9.3	0.28	33.2	0.3280	0.3574	15
Embodiment 5	8.1	0.22	36.8	0.3192	0.3448	17.6
Embodiment 6	8.1	0.26	31.2	0.3147	0.3320	17.5
Embodiment 7	7.6	0.25	30.4	0.3121	0.3255	15.5
Embodiment 8	8.3	0.25	33.2	0.3006	0.3321	18.4

In Table 1, the reflectance concerning the white and the dark is reflectance obtained with respect to a reference reflectance, for example, such as a condition assumed that brightness when barium sulfate ( $\text{BaSO}_4$ ) fluoresces is about 100 %.

Table 2

	Transmissive mode							
	Transm -ittance (%)	White (Cd/m <sup>2</sup> )	Dark (Cd/m <sup>2</sup> )	C/R	Max. C/R	White		Color Reprodu -cibility (%)
						X	Y	
Comparative Example 5	3.69	72	94	76.6	140	0.318 6	0.341 5	26.8
Comparative Example 9	7.78	140.1	133	105. 3	121. 9	0.323 9	0.333	24.9
Comparative Example 10	7.77	144.3	133	108. 5	132. 9	0.324 1	0.333 5	25.3
Comparative Example 11	7.78	149.6	187	800	90	0.332 2	0.339 3	25.2
Comparative Example 12	7.97	154.4	185	835	119.1	0.333 9	0.340 9	25.6
Embodiment 9	7.25	138.4	99	139. 8	143. 7	0.319 9	0.331 3	27.4
Embodiment 10	7.55	146.1	17	859	184. 1	0.324 4	0.335 3	26.9
Embodiment 11	7.38	143.1	123	116. 3	264. 1	0.326 3	0.336 4	27
Embodiment 12	6.8	129.3	85	152. 1	230. 2	0.323 6	0.335 3	28

The comparative example 5 is a reflective-transmissive type LCD apparatus having a substantially uniform cell gap, and each of comparative examples 6 to 9 and embodiments 5 to 8 is a reflective-transmissive type LCD apparatus having a non-uniform cell gap. Particularly, a reflective-transmissive type LCD apparatus having the top-ITO structure is used in the comparative examples 6 to 9. The comparative example 6 represents a reflective-transmissive type LCD apparatus that an edge of

an opening of a reflecting plate corresponds with a boundary of a transmitting area. The comparative example 7 represents a reflective-transmissive type LCD apparatus that an edge of an opening of a reflecting plate is spaced apart from a transmitting area by about  $0.5\mu$ . The comparative example 8 represents a reflective-transmissive type LCD apparatus that an edge of an opening of a reflecting plate is spaced apart from a transmitting area by about  $1.0\mu$ . The comparative example 9 represents a reflective-transmissive type LCD apparatus that an edge of an opening of a reflecting plate is spaced apart from a transmitting area by about  $1.5\mu$ .

A reflective-transmissive type LCD apparatus having the bottom-ITO structure is used in the embodiments 5 to 8. The reflective-transmissive type LCD apparatus in the embodiments 5 to 8 has a structure having at least two sides of a transmission window overlapped with a reflecting plate. Especially, the embodiment 5 represents a reflective-transmissive type LCD apparatus having a reflecting plate overlapped with the transmission window by about  $+0.5\mu$ . The embodiment 6 represents a reflective-transmissive type LCD apparatus having a reflecting plate overlapped with the transmission window by about  $+1.0\mu$ . The embodiment 7 represents a reflective-transmissive type LCD apparatus having a reflecting plate overlapped with the transmission window by about  $+3.0\mu$ . The embodiment 8 represents a reflective-transmissive type LCD apparatus having a reflecting plate overlapped with the transmission window by about  $+5.0\mu$ .

According to Table 1 and Table 2 as described above, the reflective-transmissive type LCD apparatus having the uniform cell gap has optical characteristics similar to those of the reflective-transmissive type LCD apparatus having the non-uniform cell gap.

In a viewpoint of the white brightness of the transmissive mode, the reflective-

transmissive type LCD apparatus having the non-uniform cell gap is superior to the reflective-transmissive type LCD apparatus having the uniform cell gap. As represented by the embodiments 5 to 8, although the edge of the opening of the reflecting plate is partially extended to the transmitting area, the optical characteristics of the reflective-transmissive type LCD apparatus are similar to those of the reflective-transmissive type LCD apparatus represented by the comparative examples 5 to 8 when the reflective-transmissive type LCD apparatus is operated in the reflective mode or the transmissive mode.

Having described the exemplary embodiments of the present invention and its advantages, it is noted that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by appended claims.

#### [EFFECT OF THE INVENTION]

According to the array substrate and the reflective-transmissive type LCD apparatus having the array substrate, the edge that defines the opening of the reflecting plate is partially extended to and overlapped with the transmission window in accordance with the rubbing direction of the liquid crystal layer. Thus, the reflective-transmissive type LCD apparatus may prevent losses of the transmittance and the reflectance thereof, and occurrence of the afterimage and leakage of the light caused by the cell gap difference between the reflecting area and the transmitting area may be also prevented.

In the reflective-transmissive type LCD apparatus having the bottom-ITO structure, the edge that defines the opening of the reflecting plate is overlapped with the transmission window in the reversed L-shape when the liquid crystal layer is rubbed in the direction of about 10 o'clock. Therefore, the reflective-transmissive

type LCD apparatus having the non-uniform cell gap may be completed without occurrence of the afterimage and leakage of the light.

Since the reflective-transmissive type LCD apparatus having the bottom-ITO structure does not need the contact hole that directly connects the reflecting plate to the drain electrode of the switching device, the reflective-transmissive type LCD apparatus may enhance the reflecting area, thereby improving the reflection efficiency.

[CLAIMS]

[CLAIM 1]

An array substrate comprising:

a substrate;

a switching device formed in a area defined by a gate line and a source line, the gate line formed in a first direction, the source line formed in the second direction and arranged in the first direction, the switching device having a gate electrode extended from the gate line, a source electrode extended from the source line and a drain electrode spaced apart from the source electrode;

a pixel electrode connected to the drain electrode; and

a reflecting plate formed on the pixel electrode so as to define a reflecting area from which a natural light is reflected and a transmitting area through which an artificial light is transmitted, the reflecting area having a portion of an edge extended to the transmitting area.

[CLAIM 2]

The array substrate of claim 1, further comprising:

a gate insulating layer formed on the switching device and the substrate;

an organic insulating layer formed on the switching device corresponding the reflecting area for exposing the drain electrode, and for exposing the substrate corresponding the transmitting area ; and

an inter-insulating layer formed on the organic insulating layer, and formed on the pixel electrode connected to the drain electrode,

wherein the reflecting plate is formed on an upper area of the inter-insulating layer, and is extended to the transmitting area from a predetermined area of an edge of the reflecting area, the upper area of the inter-insulating layer corresponding to the

reflecting area, .

[CLAIM 3]

The array substrate of claim 2, wherein the reflecting area is formed to be shifted to an opposite direction to the transmitting area in the remained area of the edge of the transmitting area.

[CLAIM 4]

The array substrate of claim 1, further comprising:

an gate insulating layer formed on the switching device and a first substrate, exposing the drain electrode;

the pixel electrode formed on the gate insulating layer and connected to the drain electrode, and an organic insulating layer formed on the switching device, for exposing the gate insulating layer corresponding to the transmitting area; and

an inter-insulating layer formed on the transmitting area of an upper area of the organic insulating layer,

wherein the reflecting plate is formed on an upper area of the inter-insulating layer, extended from a predetermined area of an edge of the reflecting area, and connected to the pixel electrode.

[CLAIM 5]

The array substrate of claim 4, wherein the reflecting plate is formed to be shifted to an opposite direction of the transmitting area in the remained area of the edge of the reflecting area.

[CLAIM 6]

The array substrate of claim 1, wherein the pixel electrode, when viewed on a plan, is separably formed from an outside of the source line by a positive distance including zero.

[CLAIM 7]

The array substrate of claim 1, wherein widths of the pixel electrode are substantially equal to or smaller than widths of the area defined by the outside of the gate line and the outside of the source line.

[CLAIM 8]

A liquid crystal display apparatus comprising:

an upper substrate having a color pixel, the color pixel having a first thickness at a position corresponding to a reflecting area and a second thickness at a position corresponding to a transmitting area, which is thicker than the first thickness;

a lower substrate having a switching device, a pixel electrode connected to a drain electrode of the switching device, and a reflecting plate formed on the pixel electrode so as to define the reflecting area from which a natural light is reflected and the transmitting area through which an artificial light is transmitted, the reflecting area having an edge partially extended to the transmitting area; and

a liquid crystal layer interposed between the upper and lower substrates, formed to have a third width corresponding to the reflecting area, and formed to have a fourth width corresponding to the transmitting area.

[CLAIM 9]

The liquid crystal display apparatus of claim 8, wherein the transmitting area is defined by the transmission window having at least three sides, and the reflecting area is connected to the pixel electrode through at least one side of the three sides of the transmission window.

[CLAIM 10]

The liquid crystal display apparatus of claim 8, wherein the transmitting area is defined by the transmission window having at least three sides, and a portion of a first



side of the three sides and a portion of a second side adjacent to the first side of the three sides are extended to be connected with the pixel electrode.

[CLAIM 11]

The liquid crystal display apparatus of claim 8, wherein the lower substrate further comprises a rubbed alignment layer formed on the reflecting plate so as to align the liquid crystal layer, and a connection shape between the reflecting plate and the pixel electrode depends upon a rubbing direction of the rubbed alignment layer.

[CLAIM 12]

The liquid crystal display apparatus of claim 11, wherein, when the pixel electrode is viewed at an upper position thereof, an area where the reflecting plate electrically connected to the pixel electrode comprises an L-shape when the rubbing direction is in a range from about 10 to about 11 o'clock, a reversed L-shape shape when the rubbing direction is in a range from about 1 to about 2 o'clock, and a substantially and horizontally straight line shape when the rubbing direction is about 12 o'clock.

[CLAIM 13]

The liquid crystal display apparatus of claim 8, wherein the lower and upper substrates further comprise a first alignment layer rubbed in a first direction and a second alignment layer rubbed in a second direction opposite to the first direction, respectively, so as to align the liquid crystal layer, so that the liquid crystal layer is aligned in a homogeneous alignment state by the first and second alignment layers.

[CLAIM 14]

The liquid crystal display apparatus of claim 8, wherein the switching device is formed in a area defined by a gate line formed in a first direction and a source line formed in the second direction,

wherein the switching device comprises a gate electrode extended from the gate line, a source electrode extended from the source line and a drain electrode spaced apart from the source electrode in a predetermined distance,

wherein the pixel electrode, when viewed in a plane, is separably formed from an outside of the source line by a positive distance including zero, and

wherein the pixel electrode is electrically connected to the drain electrode so as to receive a voltage signal provided through the drain electrode.

[CLAIM 15]

The liquid crystal display apparatus of claim 8, wherein the switching device is formed in a area defined by a gate line formed in a first direction and a source line formed in a second direction,

wherein the switching device comprises a gate electrode extended from the gate line, a source electrode extended from the source line and a drain electrode spaced apart from the source electrode in a predetermined distance,

wherein the pixel electrode are substantially equal to or smaller than an area defined by the gate line and the source line, and

wherein the pixel electrode is electrically connected to the drain electrode so as to receive a voltage signal provided through the drain electrode.

[CLAIM 16]

In a liquid crystal display apparatus that displays an image using an artificial light or a natural light passing through a liquid crystal layer, the liquid crystal display apparatus comprising:

a first substrate;

a switching device formed in a area that is defined by a gate line and a source line disposed on the first substrate, the gate line formed in a first direction, the source

line formed in a second direction;

a pixel electrode extended from a drain electrode of the switching device; and

a reflecting plate disposed on the pixel electrode so as to define a reflecting area from which the natural light is reflected and a transmitting area through which the artificial light is transmitted, the reflecting area having a portion of an edge extended to the transmitting area.

[CLAIM 17]

The liquid crystal display apparatus of claim 16, further comprising:

a gate insulating layer formed on the switching device and the first substrate;

an organic insulating layer formed on the switching device corresponding to the reflecting area for exposing the drain electrode of the switching device and for exposing the substrate corresponding to the transmitting area; and

an inter-insulating layer formed on the pixel electrode,

wherein the pixel electrode is connected to the drain electrode exposed by the organic insulating layer, and is formed on the organic insulating layer,

and the reflecting area is formed on an area corresponding to the reflecting area of an upper area of the inter-insulating layer, and the reflecting area is extended from a predetermined area of the edge of the reflecting area to the transmitting area.

[CLAIM 18]

The liquid crystal display apparatus of claim 16, further comprising:

a second substrate; and

a color pixel disposed on the second substrate, the color pixel having a first thickness at a position corresponding to the reflecting area and a second thickness at a position corresponding to the transmitting area, which is thicker than the first thickness,

wherein the liquid crystal layer is disposed between the first and second substrates, and has a third thickness at the position corresponding to the reflecting area and a fourth thickness at the position corresponding to the transmitting area, which is thicker than the third thickness.

[CLAIM 19]

The liquid crystal display apparatus of claim 18, further comprising:

a first alignment layer formed on the reflecting plate and rubbed in a first direction so as to align the liquid crystal layer; and

a second alignment layer formed on the color pixel and rubbed in a second direction opposite to the first direction so as to align the liquid crystal layer,

wherein the liquid crystal layer is aligned in a homogeneous alignment state by the first and second alignment layers.

[CLAIM 20]

In a liquid crystal display apparatus that displays an image using an artificial light or a natural light passing through a liquid crystal layer, the liquid crystal display apparatus comprising:

a first substrate;

a switching device formed in a pixel area that is defined by a gate line and a source line disposed on the first substrate, the gate line formed in a first direction, the source line formed in a second direction, and the switching device having a gate electrode extended from the gate line, a source electrode extended from the source line and a drain electrode spaced apart from the source electrode;

a gate insulating layer formed on the switching device and the substrate;

a pixel electrode formed on the gate insulating layer and connected to the drain electrode, for exposing the drain electrode of the switching device;

an organic insulating layer formed on the switching device and the pixel electrode to expose the gate insulating layer corresponding to the transmitting area;

an inter-insulating layer formed on the organic layer corresponding to the reflecting area; and

a reflecting plate disposed on the pixel electrode so as to define the reflecting area and the transmitting area, the reflecting area having a first edge extended to the transmitting area to connect the reflecting plate to the pixel electrode.

[CLAIM 21]

The liquid crystal display apparatus of claim 20, further comprising:

a second substrate; and

a color pixel disposed on the second substrate, the color pixel having a first thickness at a position corresponding to the reflecting area and a second thickness at a position corresponding to the transmitting area, which is thicker than the first thickness,

wherein the liquid crystal layer is disposed between the first and second substrates, and has a third thickness at the position corresponding to the reflecting area and a fourth thickness at the position corresponding to the transmitting area, which is thicker than the third thickness.

[CLAIM 22]

The liquid crystal display apparatus of claim 20, further comprising:

a first alignment layer formed on the reflecting plate and rubbed in a first direction; and

a second alignment layer formed on the color pixel and rubbed in a second direction opposite to the first direction,

wherein the liquid crystal layer is aligned in a homogeneous alignment state by

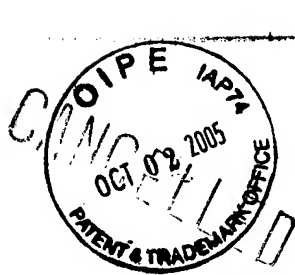
the first and second alignment layers.

[CLAIM 23]

The liquid crystal display apparatus of claim 20, wherein the pixel electrode, when viewed in a plane, is separably formed from an outside of the source line by a positive distance including zero.

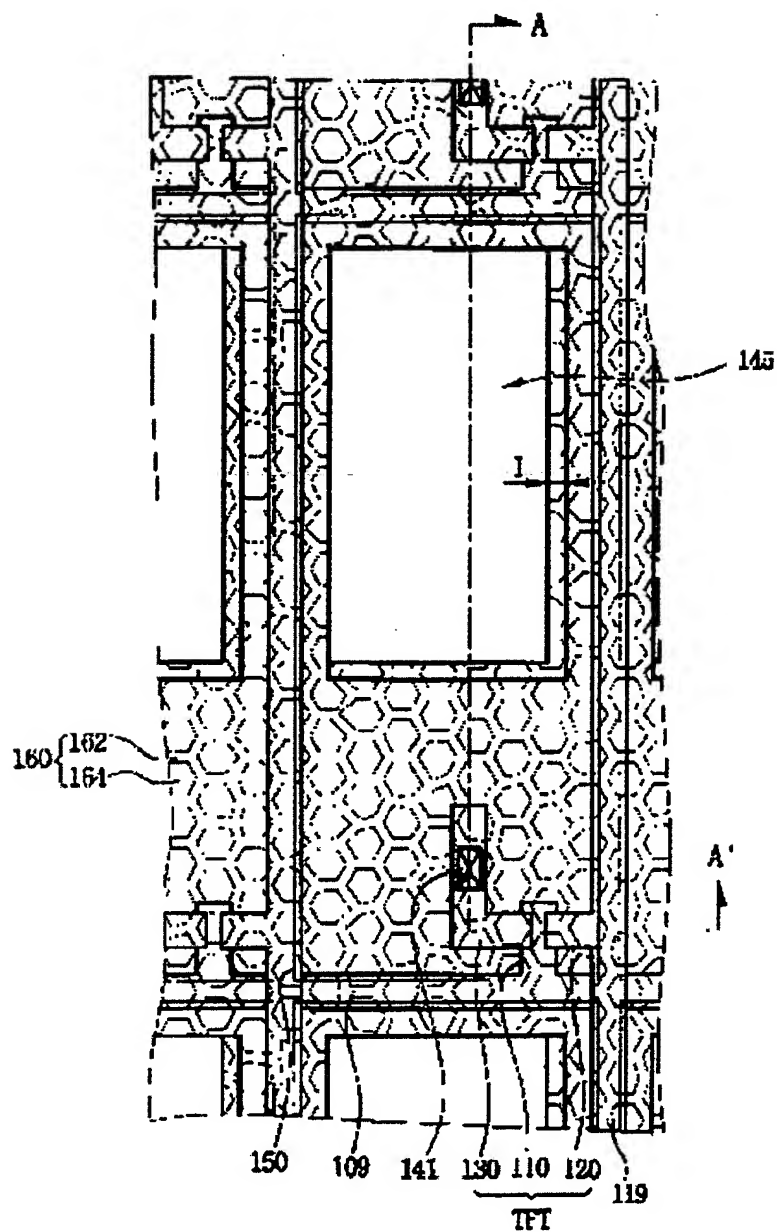
[CLAIM 24]

The liquid crystal display apparatus of claim 20, wherein the pixel electrode are substantially equal to or smaller than an area defined by an outside of the gate line and the outside of the source line.

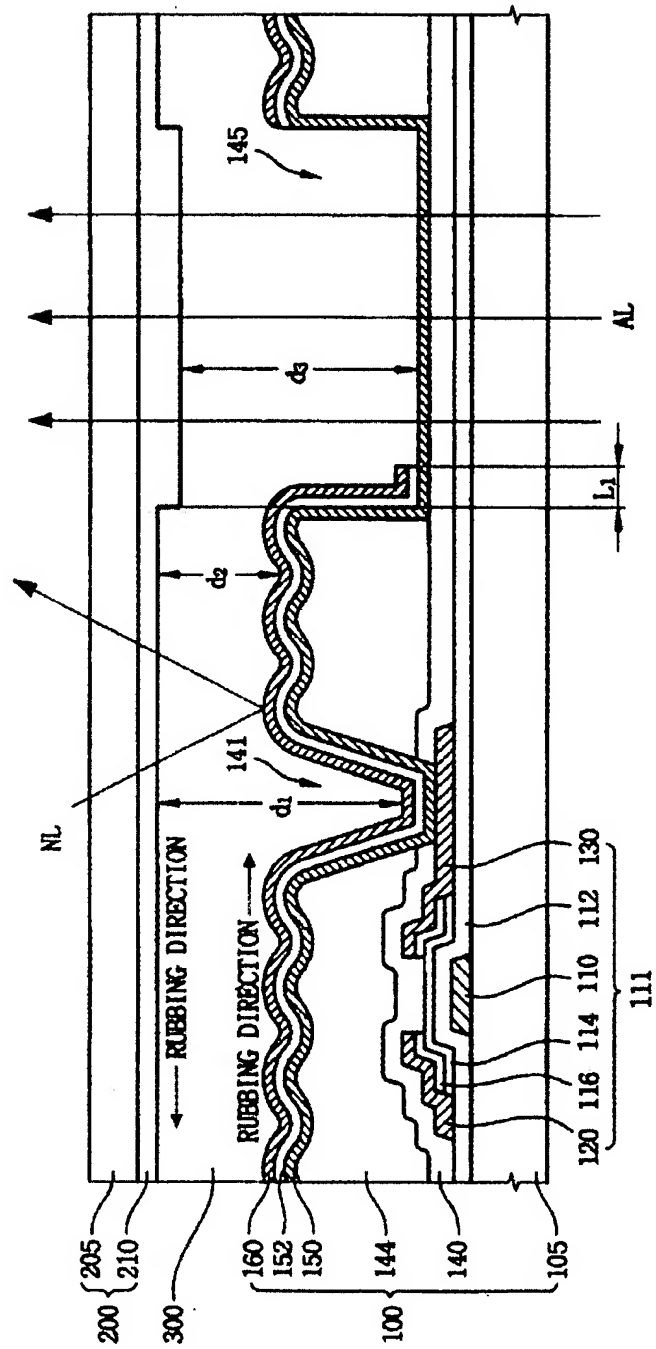


[DRAWING]

[FIG. 1]

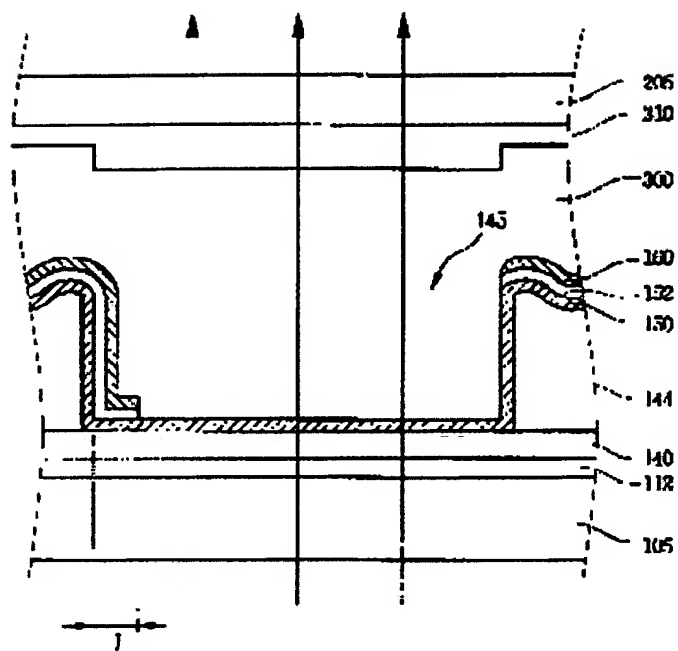


[FIG. 2]

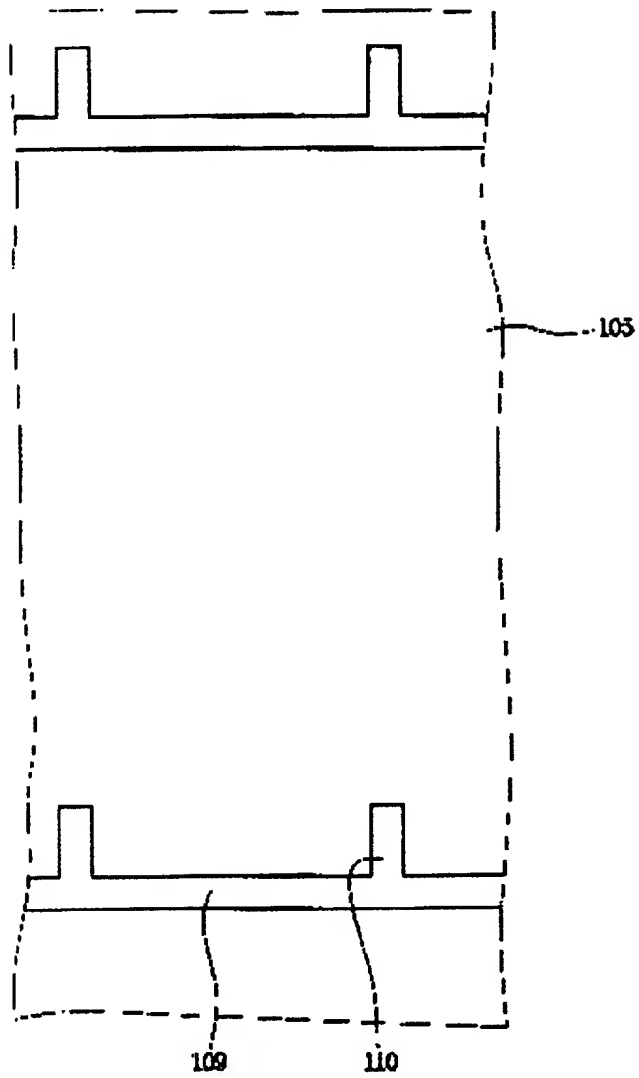




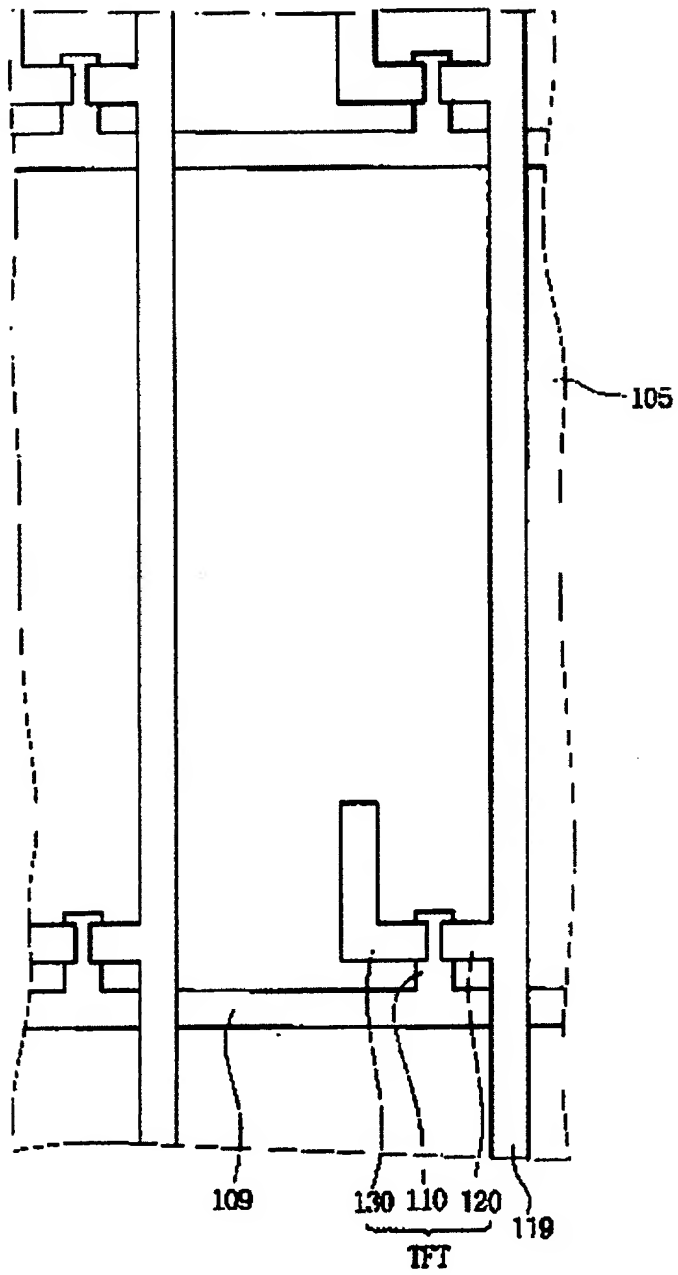
[FIG. 3]



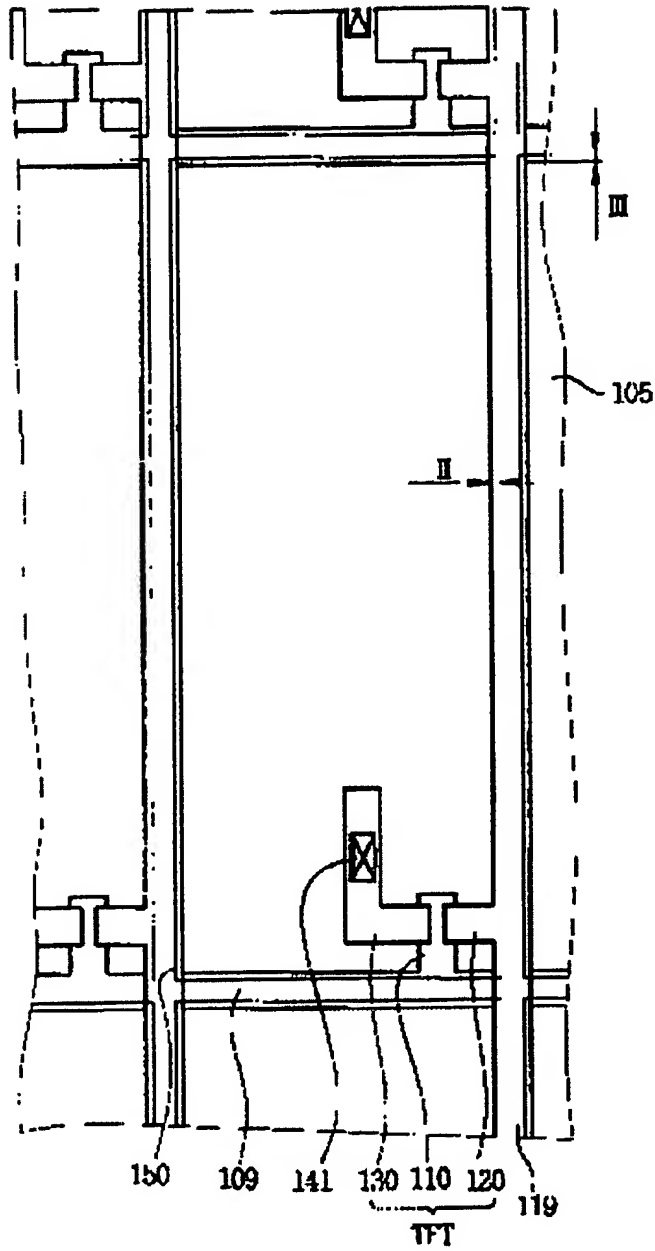
[FIG. 4a]



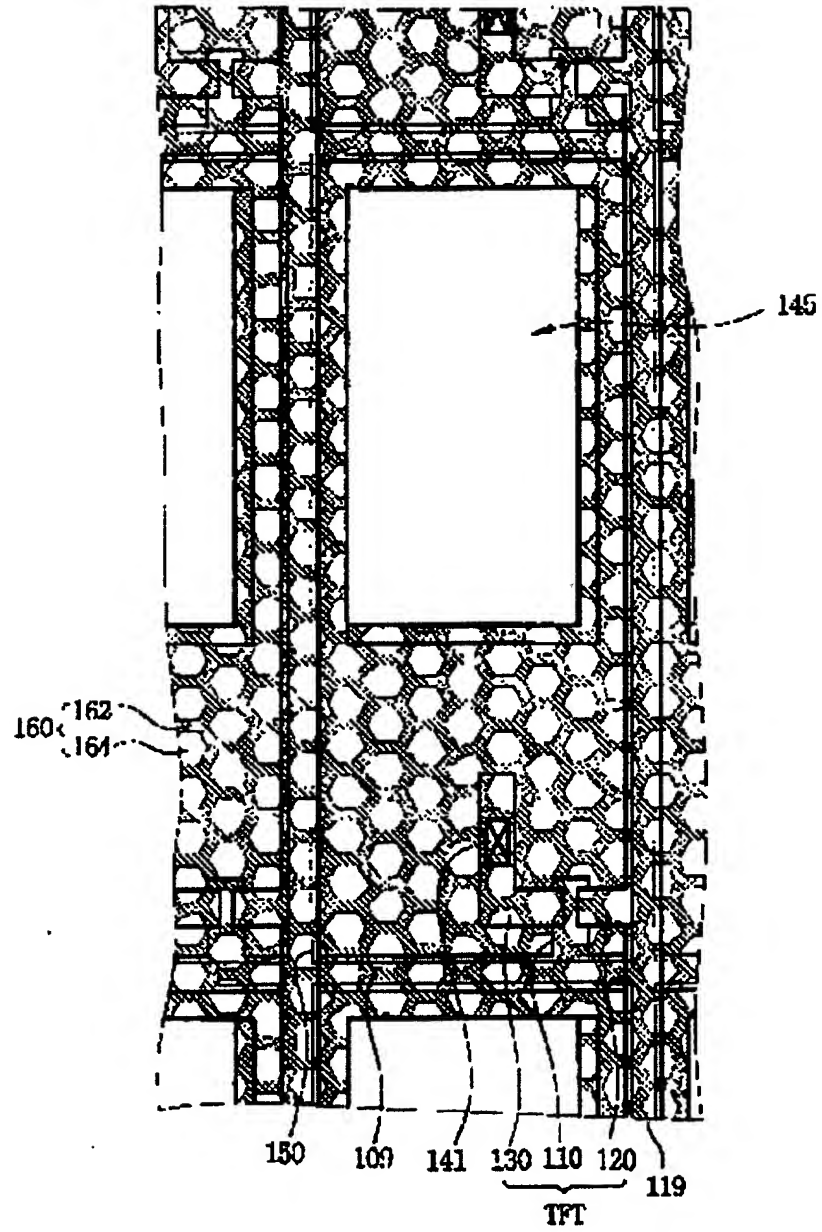
[FIG. 4b]



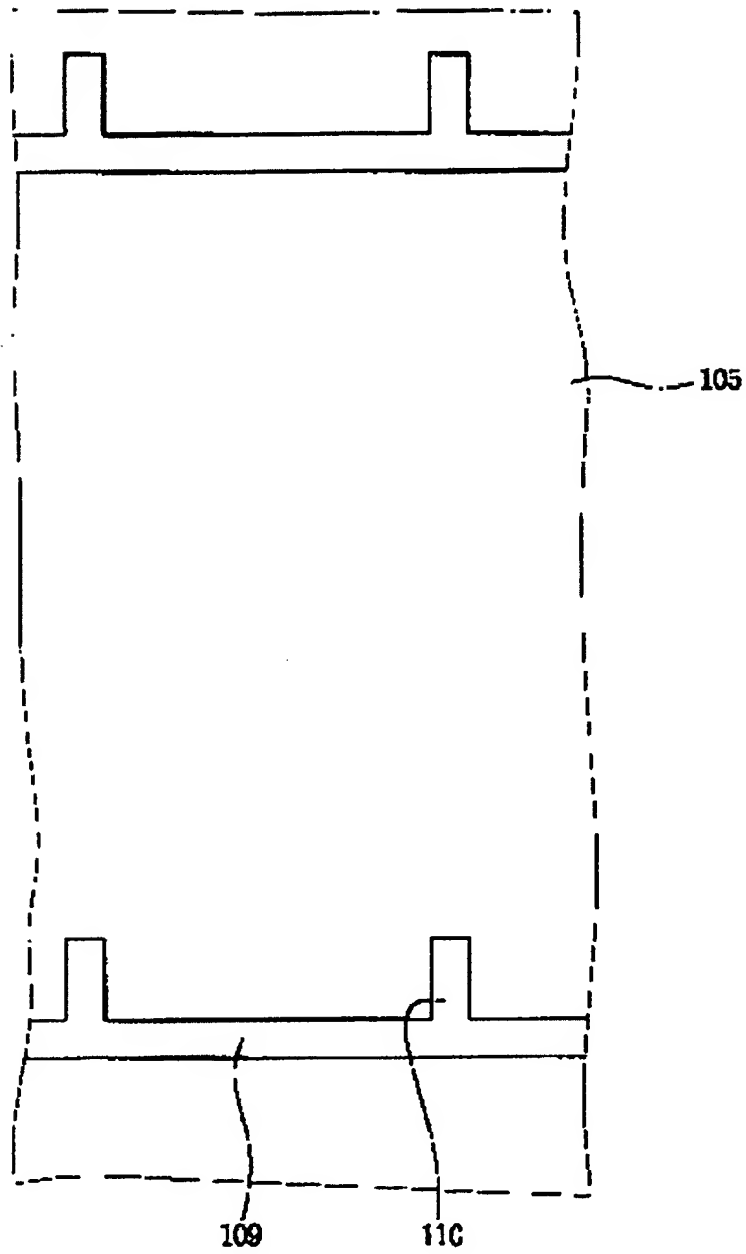
[FIG. 4c]



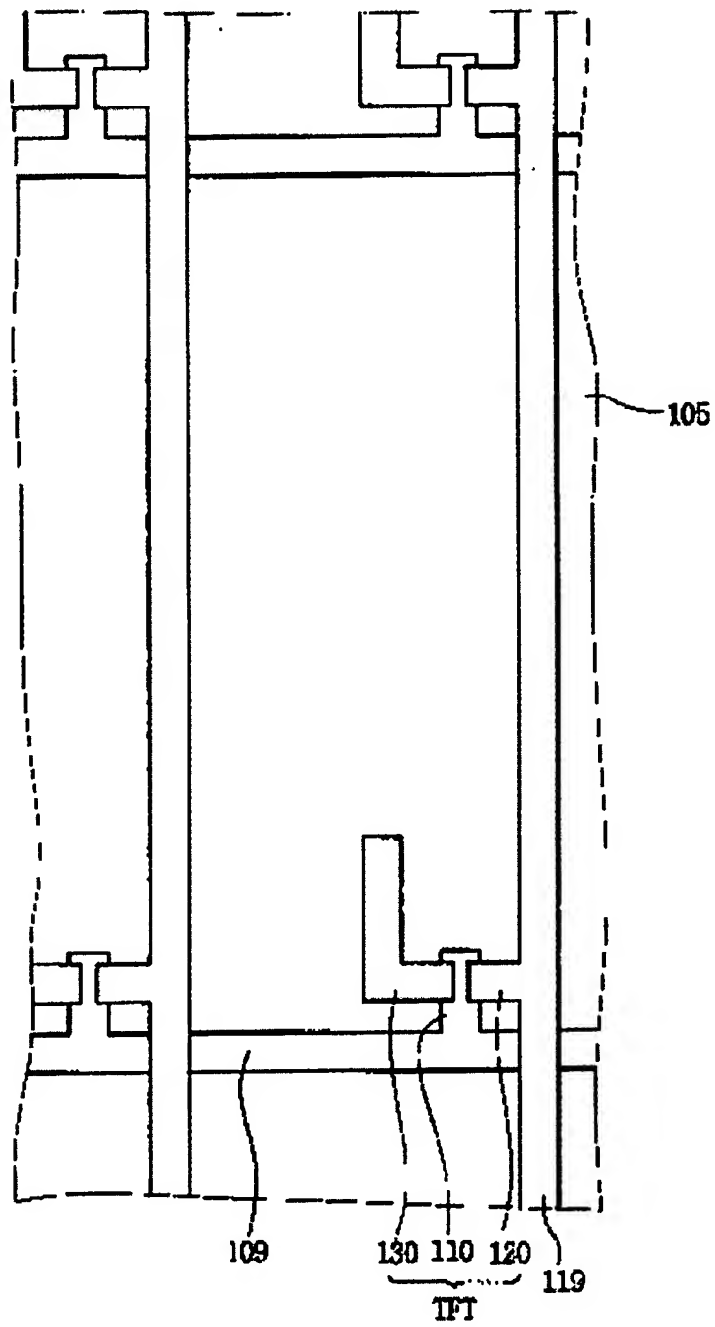
[FIG. 4d]



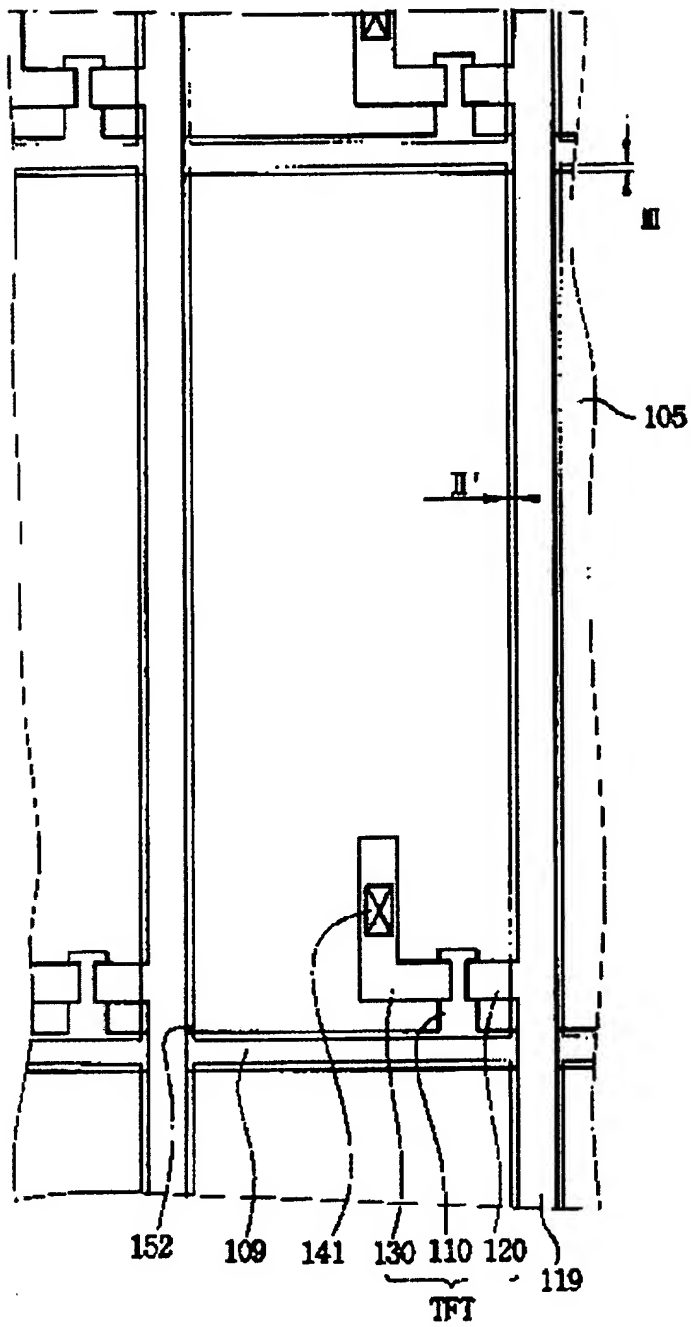
[FIG. 5a]



[FIG. 5b]

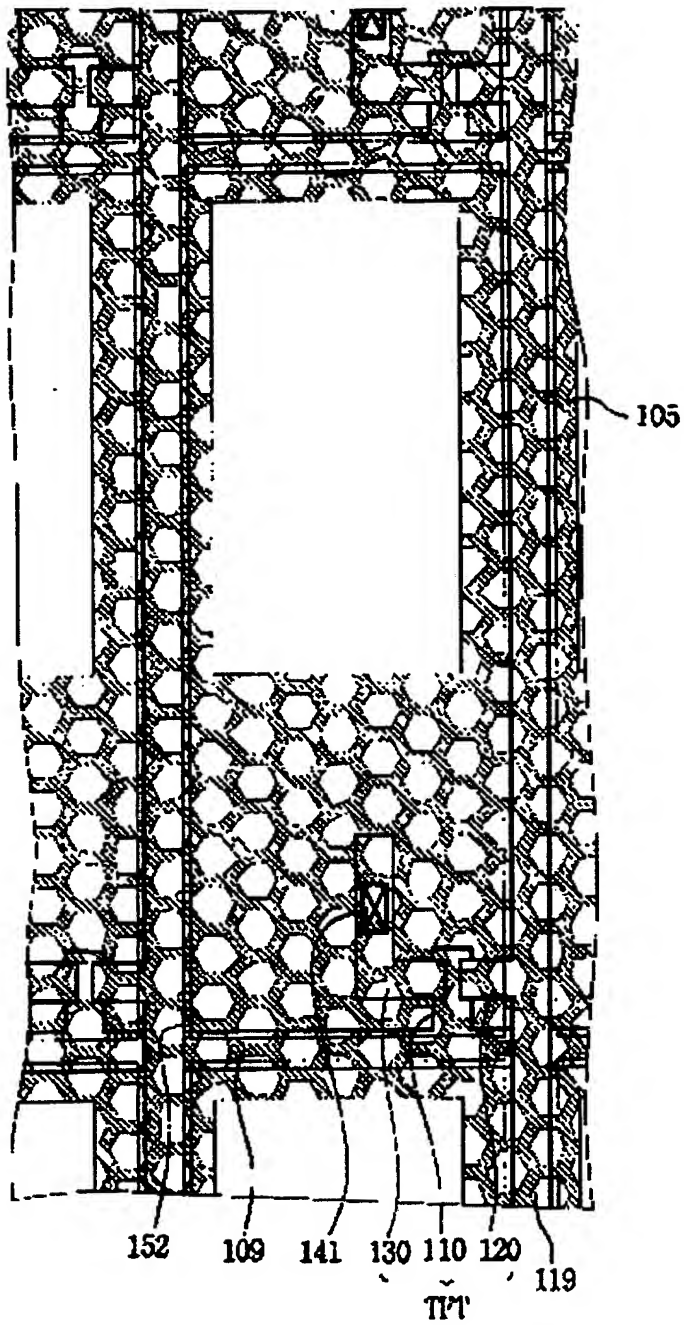


[FIG. 5c]

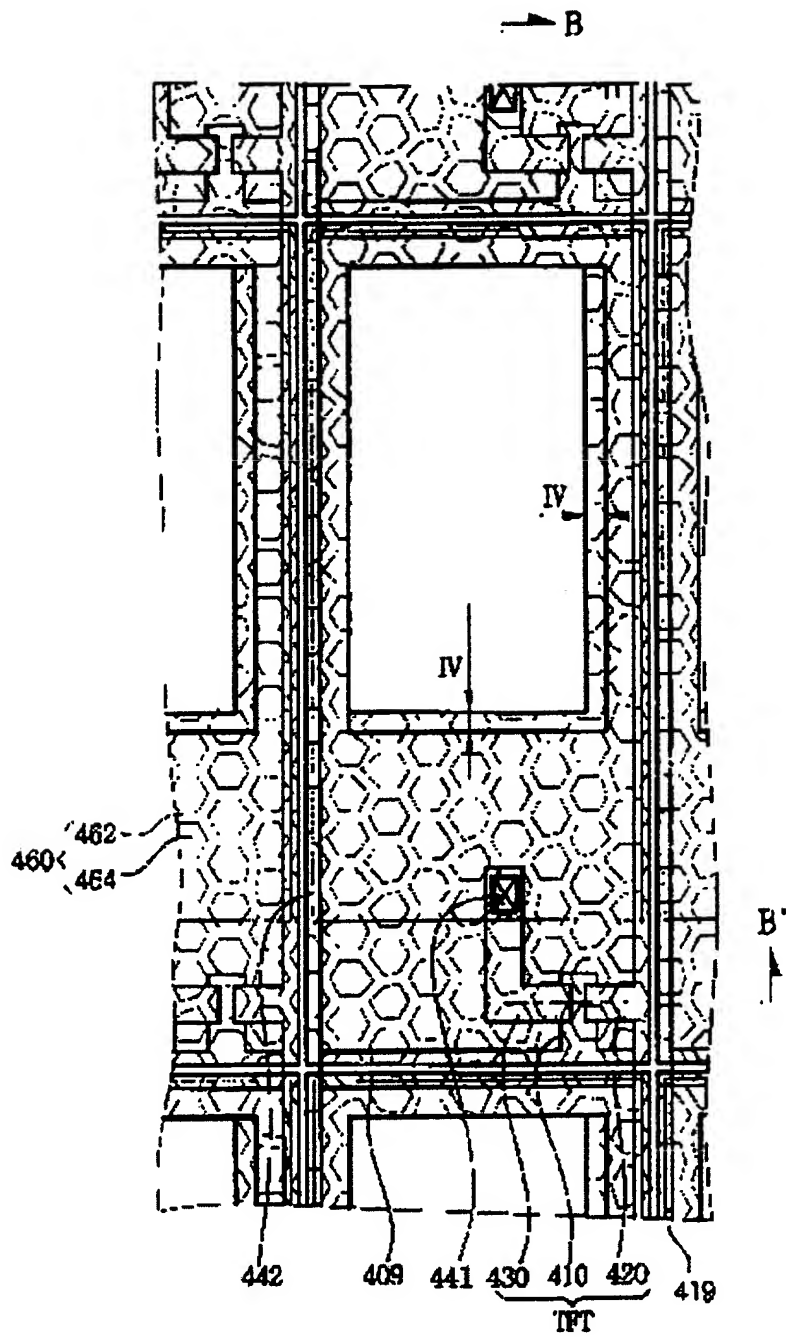




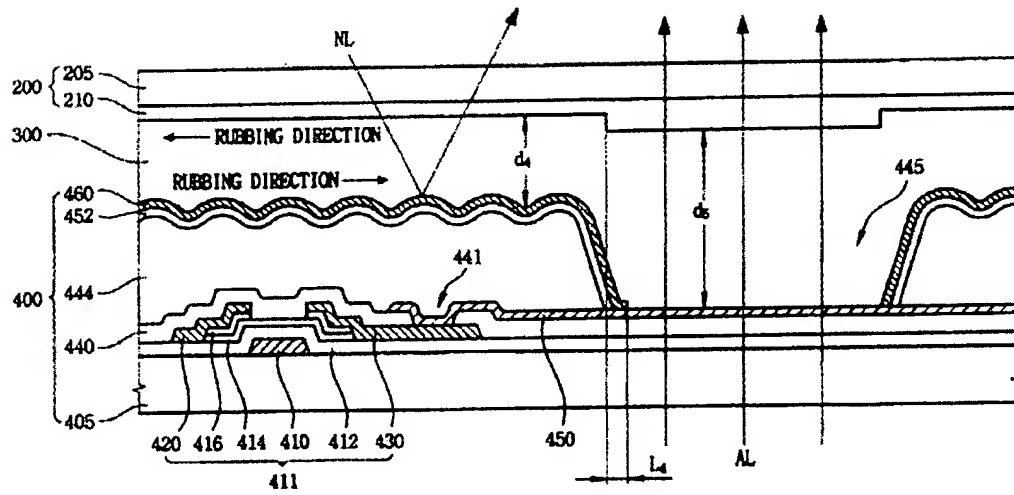
[FIG. 5d]



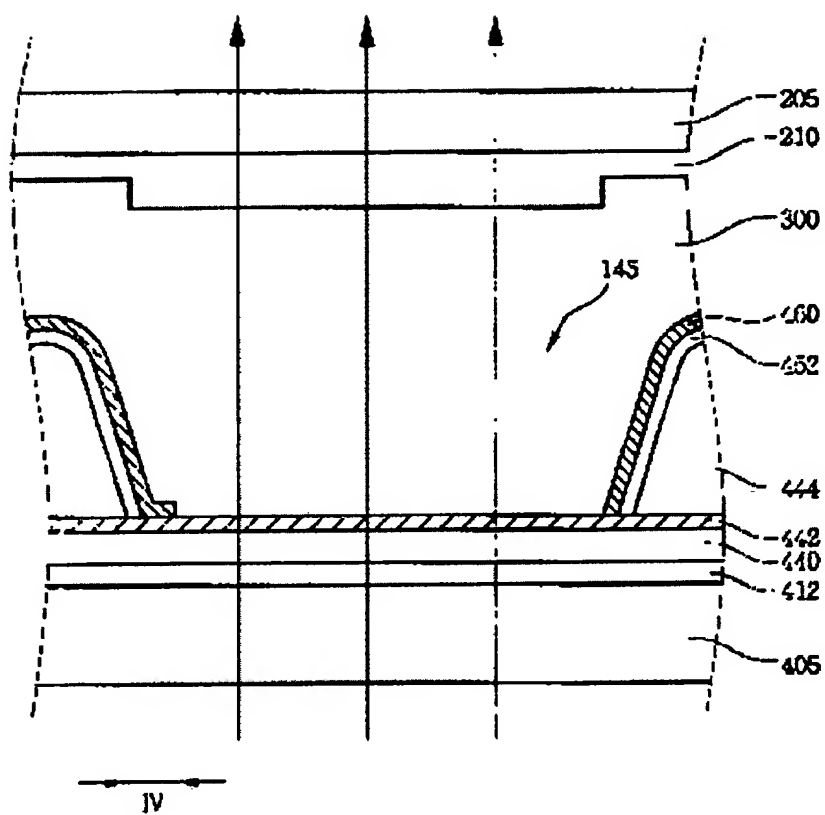
[FIG. 6]



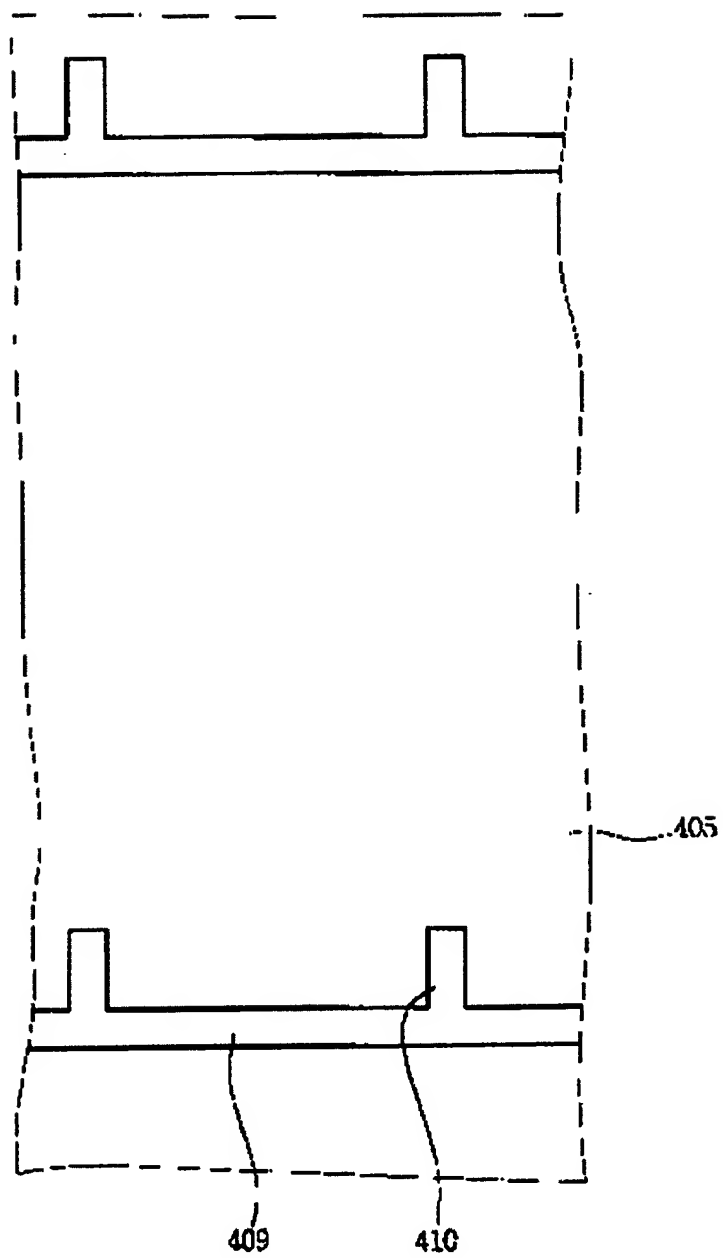
[FIG. 7]



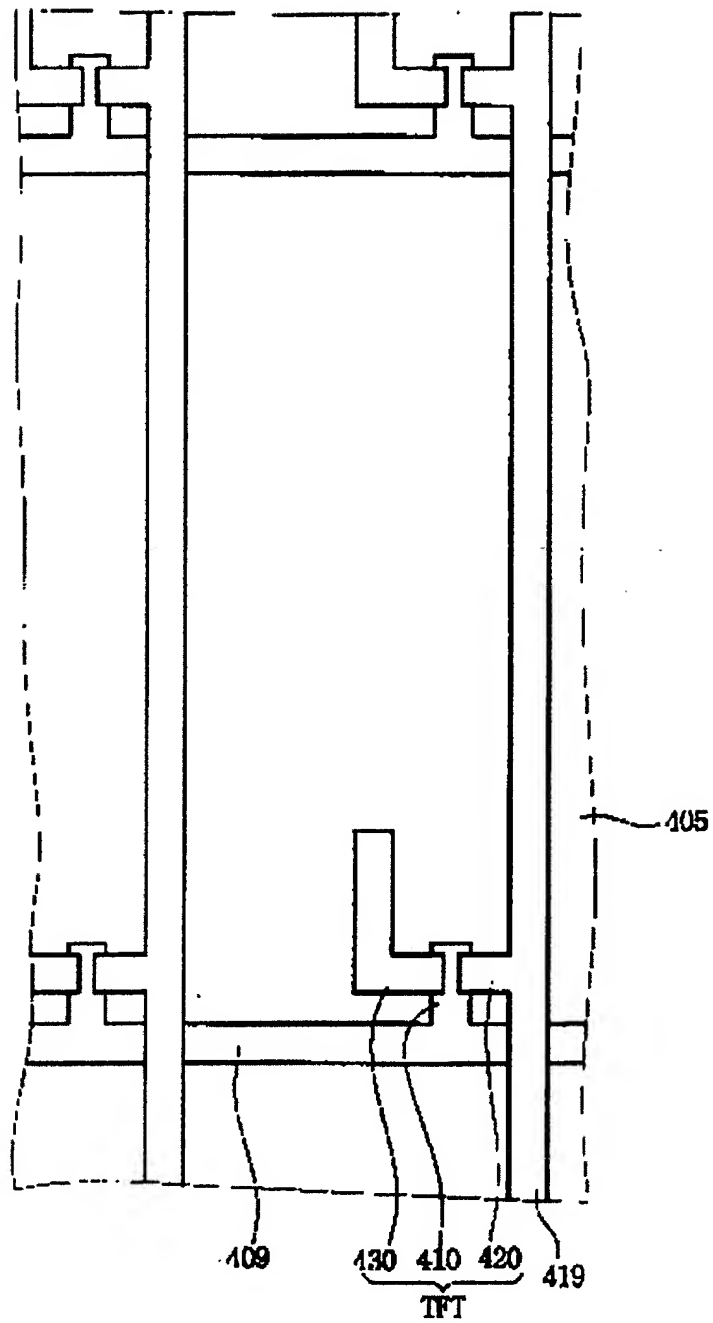
[FIG. 8]



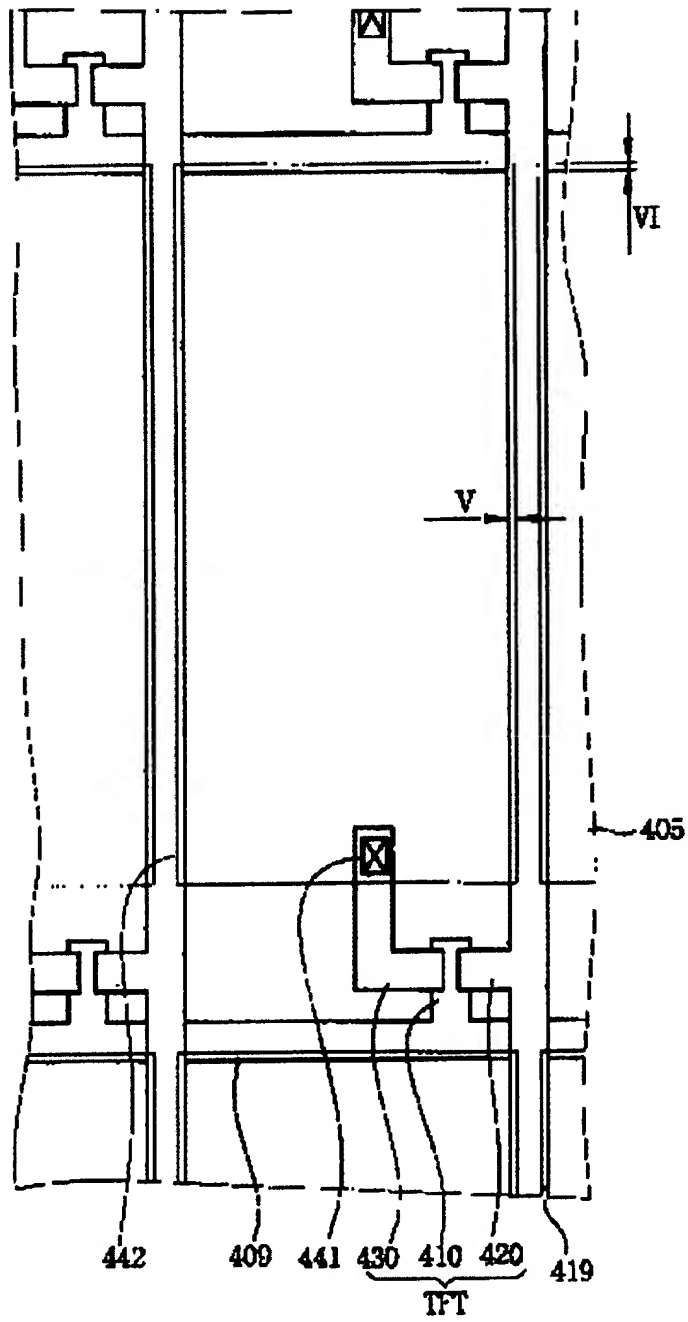
[FIG. 9a]



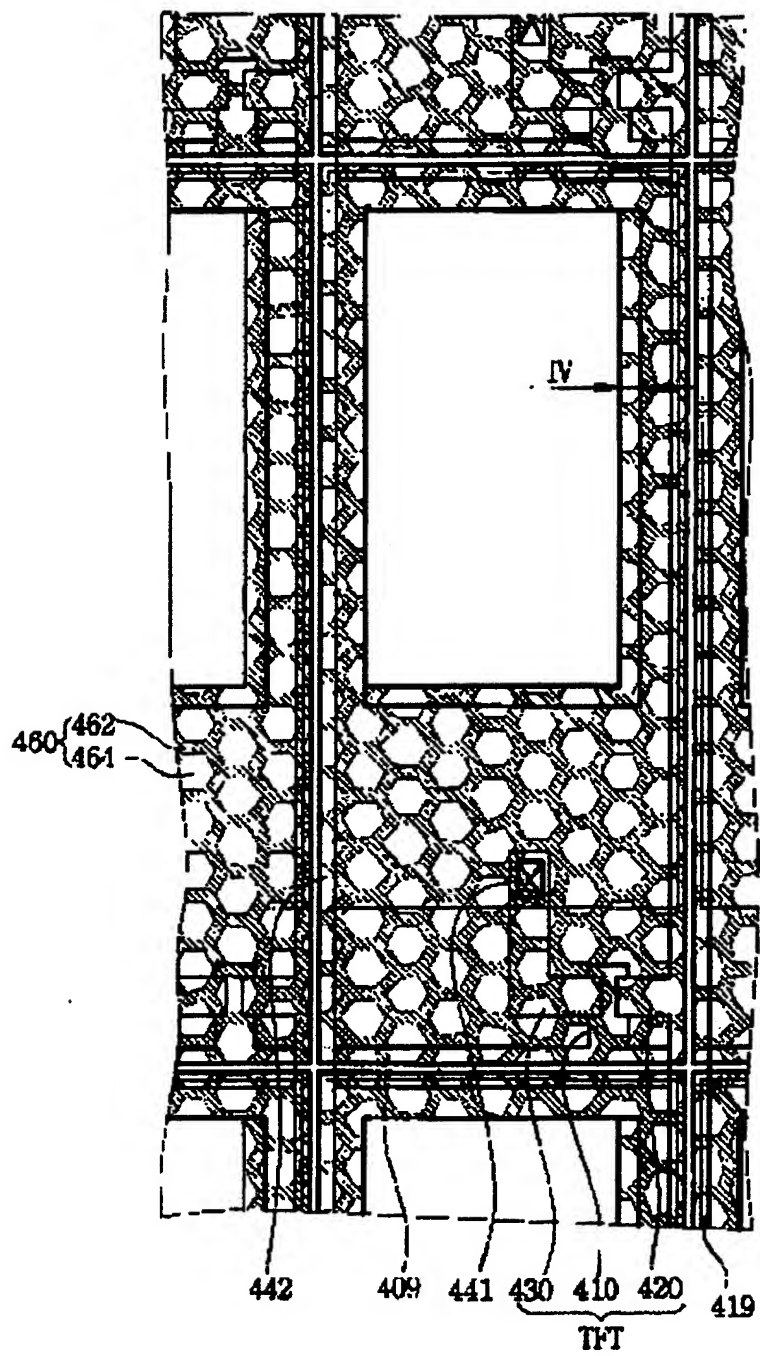
[FIG. 9b]



[FIG. 9c]

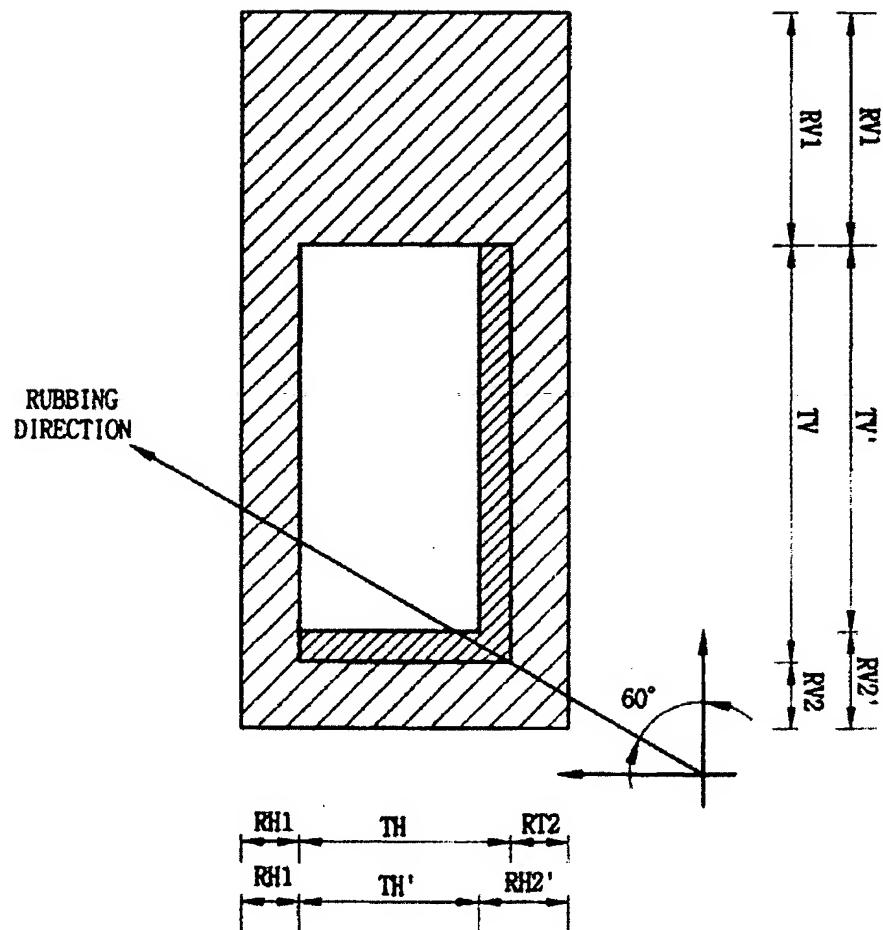


[FIG. 9d]

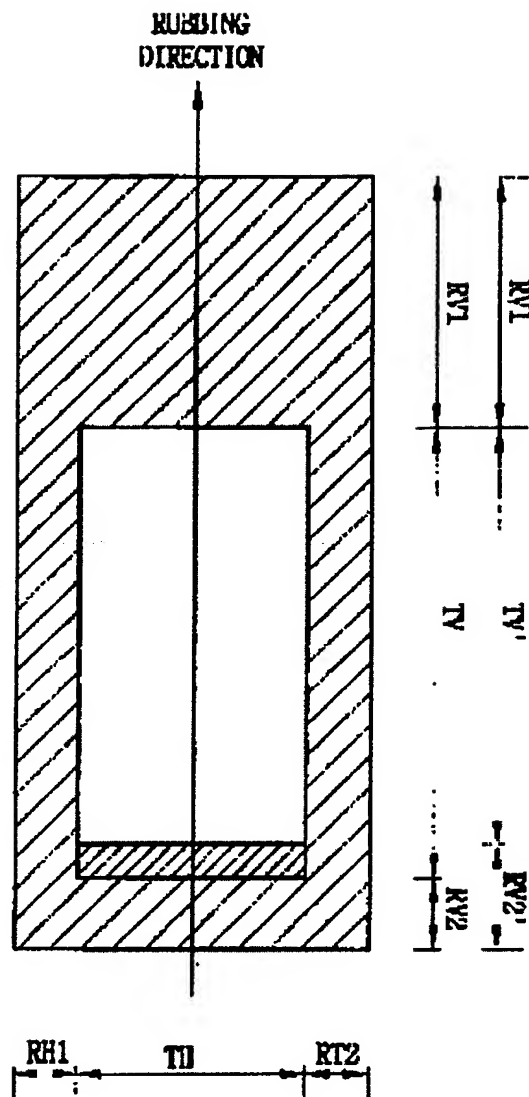




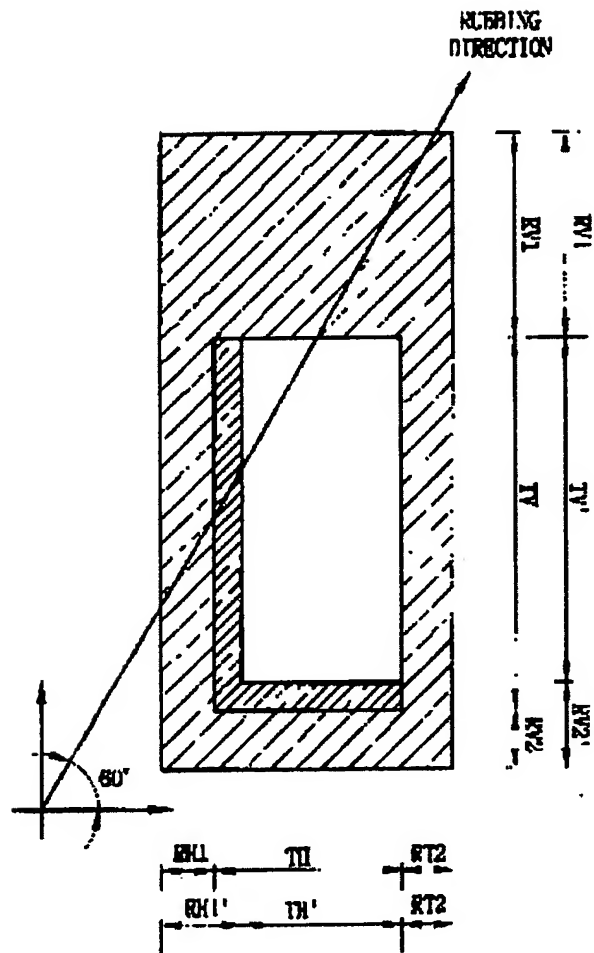
[FIG. 10]



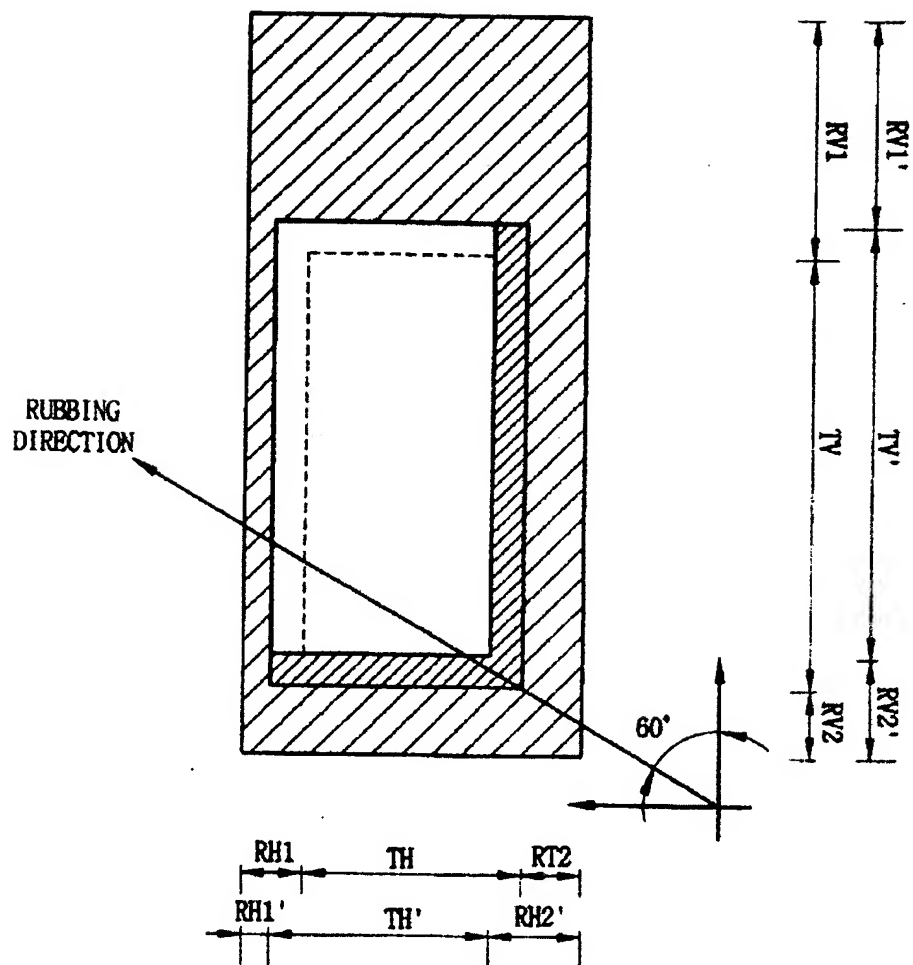
[FIG. 11]



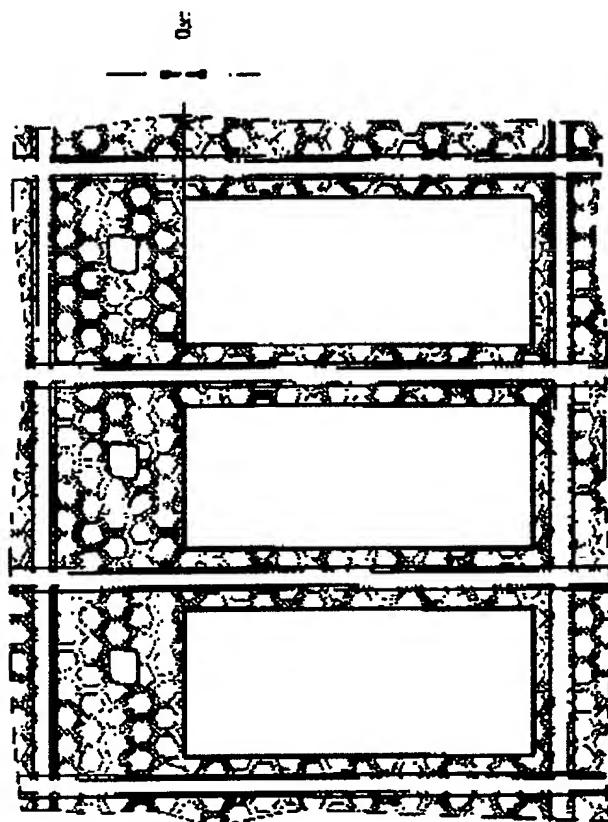
[FIG. 12]



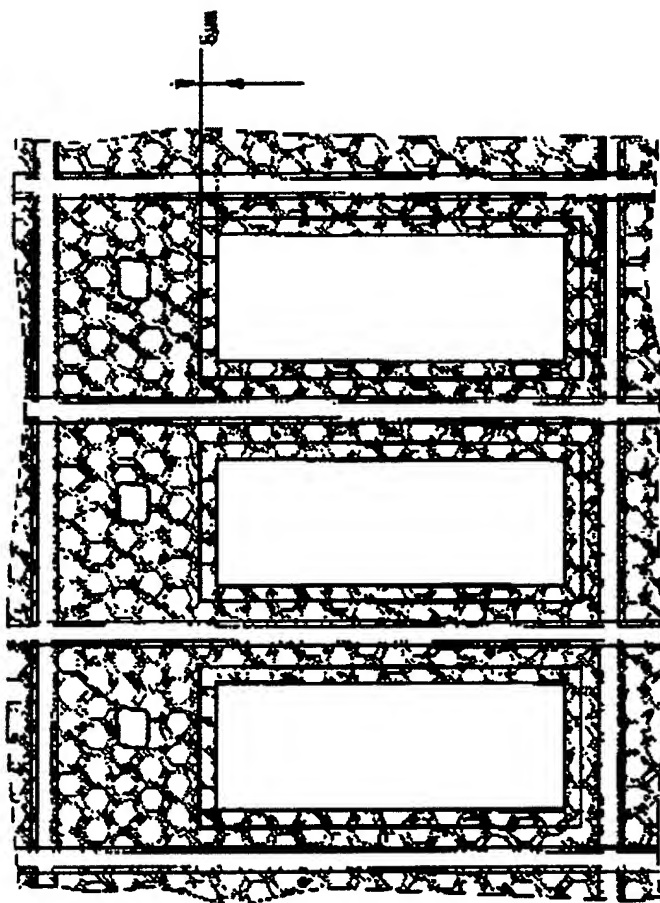
[FIG. 13]



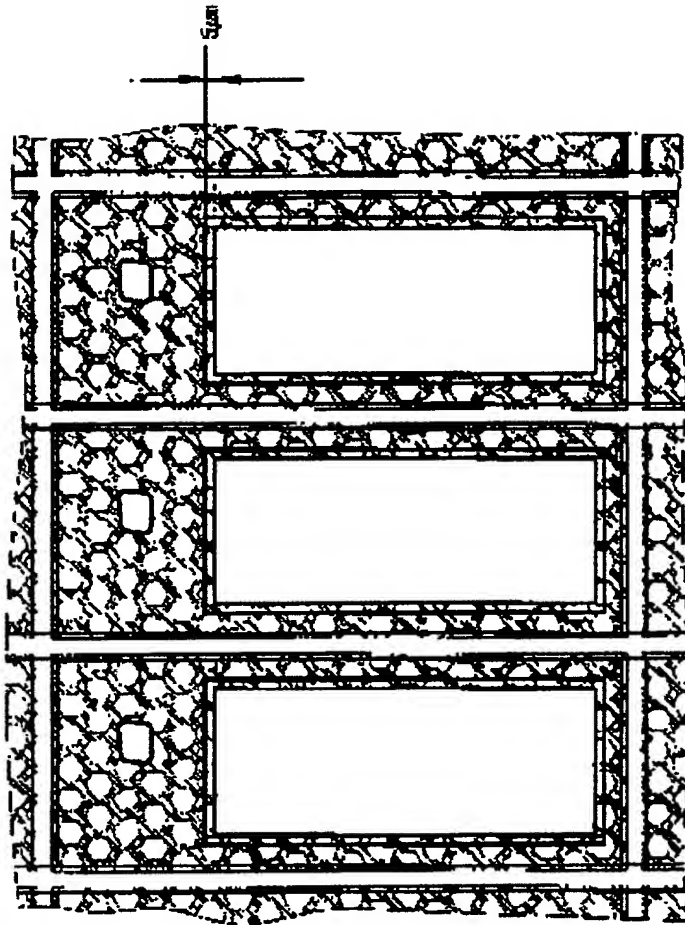
[FIG. 14a]



[FIG. 14b]



[FIG. 14c]



[FIG. 14d]

